ORNL/TM-11735

ornl

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

High Temperature Materials Laboratory Third Annual Report (October 1989 through September 1990)

V. J. Tennery
F. M. Foust

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/TM-11735

Metals and Ceramics Division

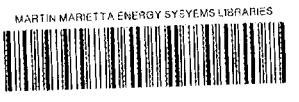
HIGH TEMPERATURE MATERIALS LABORATORY THIRD ANNUAL REPORT (OCTOBER 1989 THROUGH SEPTEMBER 1990)

V. J. Tennery
F. M. Foust

Date Published: December 1990

Prepared for
U.S. Department of Energy
Assistant Secretary for Conservation and Renewable Energy
Office of Transportation Technologies
EE 06 00 00 0

Prepared by
High Temperature Materials Laboratory
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6285
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400



CONTENTS

HIGH TEMPERATURE MATERIALS LABORATORY THIRD ANNUAL REPORT* (OCTOBER 1989 THROUGH SEPTEMBER 1990)

V. J. Tennery and F. M. Foust

ABSTRACT

The High Temperature Materials Laboratory has completed its third year of operation as a designated DOE User Facility at the Oak Ridge National Laboratory. Growth of the user program is evidenced by the number of outside institutions who have executed user agreements since the facility began operation in 1987. A total of 88 nonproprietary agreements (40 university and 48 industry) and 20 proprietary agreements (1 university, 19 industry) are now in effect.

Sixty-eight nonproprietary research proposals (39 from university, 28 from industry, and 1 other government facility) and 8 proprietary proposals were considered during this reporting period. Research projects active in FY 1990 are summarized.

INTRODUCTION

The High Temperature Materials Laboratory (HTML) is a modern research facility which houses an array of special research equipment used to meet research needs for advanced high-temperature materials, including structural ceramics and alloys. The research instruments in the original four HTML User Centers provide a comprehensive set of tools for performing state-of-the-art determination of the structure and properties of solids. A key part of the HTML concept includes a staff of highly trained technical personnel who interact with industrial and university researchers in this Department of Energy (DOE)-designated National User Facility. The User Centers are organized to provide materials characterization support to appropriate university and industrial users and to research programs throughout the local DOE facilities. Support includes a wide range of involvements with research personnel such as (1) conducting research relating materials properties to structure, (2) characterization of one-of-a-kind specimens, and (3) training qualified users and then providing them access to equipment to perform their own materials research.

User Agreements were developed which establish the intellectual property and liability rights of the user institution and the Oak Ridge National Laboratory (ORNL). The first official User Agreement was signed on July 15, 1987. Since that time, over 100 agreements have been executed. The first users from the university and industrial community started their research projects in August of 1987.

*Research sponsored by the Department of Energy, Assistant Secretary for Conservation and Renewable Energy, Office of Transportation Technologies, as part of the High Temperature Materials Laboratory User Program, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

Approval was received during this reporting period to start two new user centers: (1) X-Ray Residual Stress and (2) Ceramic Specimen Preparation. A more complete description of these new centers is included in Appendix A with the descriptions of the capabilities of the four original User Centers. A listing of the HTML User Center staff is also included in Appendix A.

COMMITTEE ACTIVITIES

Three advisory committees assist in the successful operation of the HTML User Program. These committees are listed below with a brief description of their organization, function, and activities during the past year. A listing of members of these committees is included in Appendix B.

Advisory Committee. This senior committee has the responsibility of advising the HTML Director on policy for operation of the User Centers. It is composed of six members who represent the industrial and academic communities. The Committee meets at least annually and more frequently when its advice is urgently required on particular matters. A formal report containing conclusions resulting from a meeting of the Committee is submitted to the Associate Director of Physical Sciences of ORNL.

User Advisory Committee. The responsibility of this committee is to review nonproprietary research proposals and make recommendations to the HTML Director as to their acceptability. It is composed of six members - two from industry, one from a university, one from DOE, one from the M&C Division staff, and the HTML Director, who serves as the permanent chairman. A more detailed description of this committee's function and responsibilities is given in the brochure, User Program for the High Temperature Materials Laboratory. This committee reviewed 68 research proposals in FY 1990 (January, March, June, and August).

HTML User Exchange Group. This group was formed and a first meeting held in the HTML on August 18, 1989. A second meeting is in the planning stages. Present, past, and potential users of the HTML are invited to these meetings, which provide current and past users an opportunity to give advice on how the user program can be improved and made more effective.

USER AGREEMENTS

There are two User Agreements utilized in the HTML User Program. The "Standard Nonproprietary Agreement" is for research projects whose results are reported in the open literature within six months of the completion of the project in the HTML. The "Standard Proprietary Agreement" is used for all projects in which the user desires that the data and results be proprietary. Table 1 is a listing of institutions who have executed nonproprietary user agreements to date.

USERS

A cumulative summary of user activity since the start of the User Program is included as Appendix C.

Table 1. Standard User Agreements executed July 15, 1987 through September 30, 1990

AGREEMENTS EXECUTED JULY 15, 1987 THROUGH SEPTEMBER 1988

UNIVERSITIES

Alfred University
Auburn University
Clemson University
Dartmouth College
Georgia Institute of Technology
New Mexico Institute of Mining and Technology
North Carolina State University
Oklahoma State University
Pennsylvania State University
Southern Illinois University
University of Alabama
University of Illinois
University of Michigan
University of New Mexico
University of Southern California
University of Tennessee
Vanderbilt University
Virginia Polytechnic Institute and State University

INDUSTRIES

Allied Signal
American Matrix, Inc.
Ceramics Process Systems Corp.
Dow Corning Corp./Midland
Great Lakes Research Corp.
Norton Company
Nuclear & Aerospace Materials Corp.
Selee Corp.

PROPRIETARY* - 3 Agreements

AGREEMENTS EXECUTED OCTOBER 1988 THROUGH SEPTEMBER 1989

UNIVERSITIES

Johns Hopkins University
Marquette University
Rice University
Southern University
University of California at Los Angeles
University of Denver
University of Florida
University of Minnesota
University of Missouri-Rolla
University of Utah

INDUSTRIES

Carborundum Company
Coors Ceramics Company
DG Trim Products
Dow Chemical Company
Energy Conversion Devices, Inc.
Foster-Miller, Inc.
GTE Laboratories, Inc.
IMTech Company
Institute for Defense Analysis
Ionic Atlanta, Inc.
Litton Industries
Sullivan Mining Corp.
Tennessee Center for R&D
Textron Specialty Materials
Thermacore, Inc.
Third Millennium Technologies, Inc.
Universal Energy Systems, Inc.

Table 1. Continued

OTHER GOVERNMENT FACILITIES

Albany Research Center (Bureau of Mines)
EG&G Mound
National Institute of Standards and Technology

PROPRIETARY* - 6 Agreements

AGREEMENTS EXECUTED OCTOBER 1989 THROUGH SEPTEMBER 1990

UNIVERSITIES

Brown University
Illinois Institute of Technology
Kent State University
Lehigh University
Michigan Technology University
Rice University
Rutgers University
Tuskegee University
University of Arizona
University of Cincinnati
University of Delaware
University of South Carolina

INDUSTRIES

Allison Gas Turbine-Division of General Motors
Aluminum Co. of America
CarboMedics, Inc.
Certainteed Corporation
Cummins Engine Company
Detroit Diesel Corporation
Engelhard Corporation
Ford Motor Company
McDonald Douglas Missile Systems Company
Miniature Precision Bearings
Monarch Tile, Inc.
Norton/TRW Ceramics
Proctor & Gamble Company
Refractory Testing Associates
ReMaxCo Technologies, Inc.
SB&TD Business Systems
Sundstrand Power Systems-
Division, Sundstrand Corp.
Teledyne Allvac
United Technologies Corporation

OTHER GOVERNMENT FACILITIES

U.S. Bureau of Mines Tuscaloosa Research Center

PROPRIETARY* - 11 Agreements

*Due to the sensitive nature of many of these research activities, the names of the user institutions for proprietary agreements are not listed.

The category of users and number of user days accumulated during this third year of HTML operation are shown in Table 2.

Table 2. HTML FY 1990 User Experience

Type of user	Number of		User days
	institutions	individuals	
Industry	30	53	956
University	19	40	607
Local Oak Ridge users	2	90	1758

Figure 1 shows the total number of user days per quarter during FY 1990. The industrial user days varied from about 209 to 271 during a particular quarter, university user days ranged from 122 to 175, and local user days ranged from 348 to 592. Figure 2 shows the number of user days for all industrial and university users in the HTML for each quarter of FY 1990.

A short summary of the research performed by nonproprietary users is given for each User organization. A listing of publications and presentations resulting from user research projects is given in Appendix D.

To date, 180 research proposals have been received in the User Program. The status of these is given in Table 3. Access clearances were initiated on 290 individual researchers who were listed as principal investigators on these proposals.

Table 3. Status of research proposals submitted July 1987 through September 1990

User Type	Research Proposals						
	Submitted	Approved	Rejected	Withdrawn	Active	Pending	Completed
Industry	70	57	0	11	25	10	24
University	92	86	1	12	55	2	22
Other Government	4	4	0	0	2	1	1
Total Nonproprietary	166	147	1	23	82	13	47
Proprietary	14	11	0	3	6	1	4
Grand Totals	180	158	1	26	88	14	51

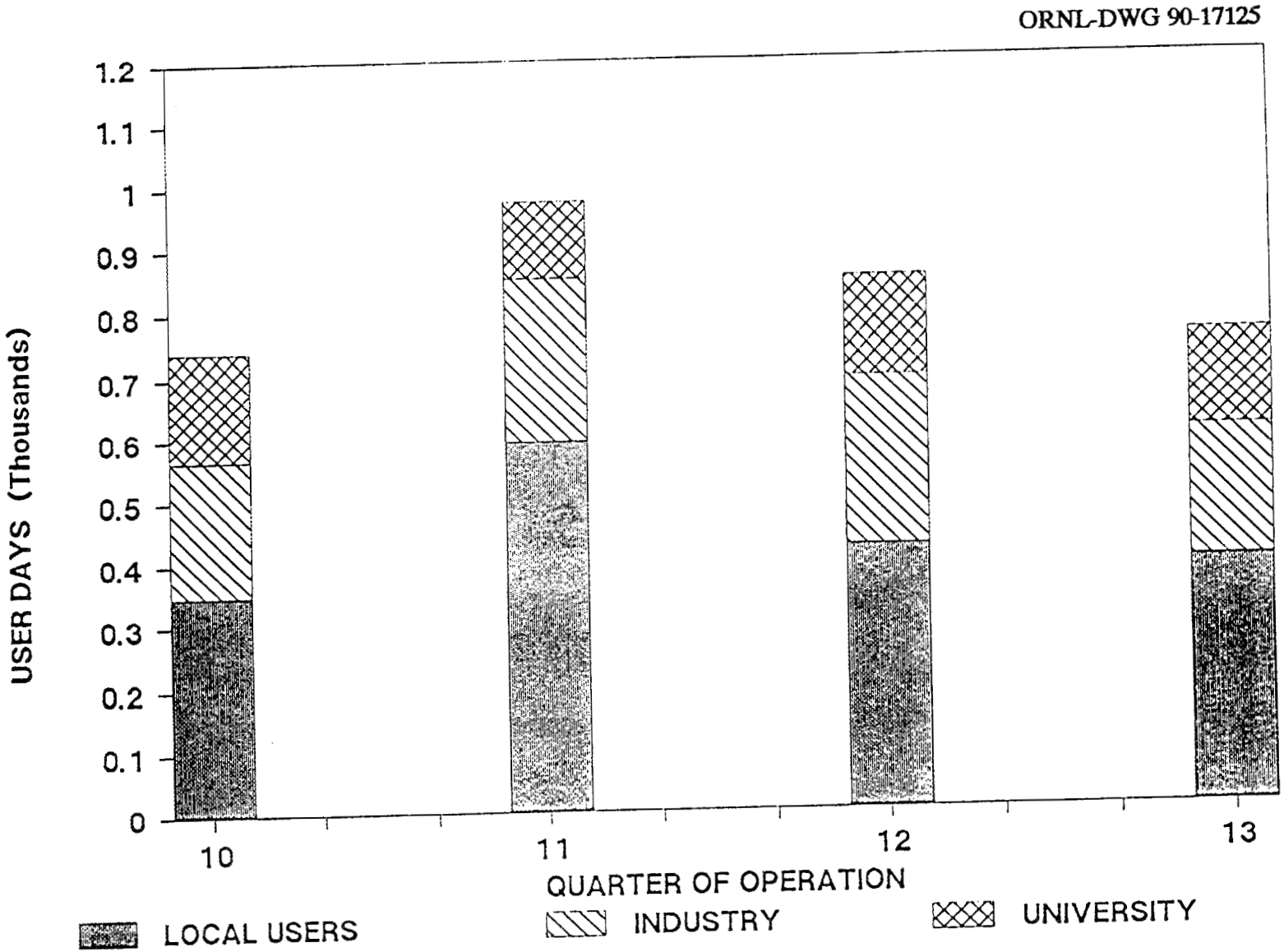


Fig. 1. Total HTML user days in FY 1990.

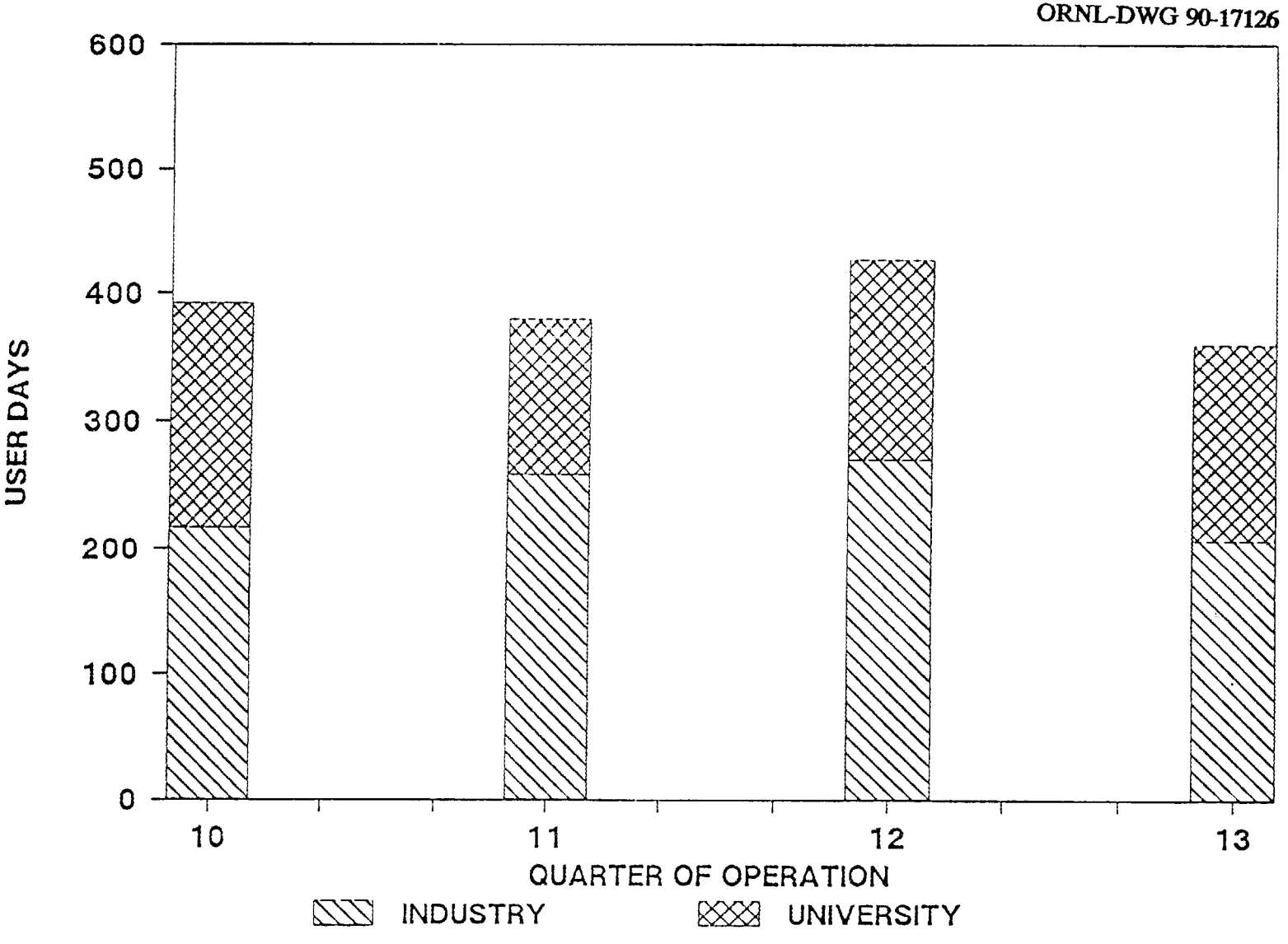


Fig. 2. Total industrial and university user days in the HTML in FY 1990.

INDUSTRIAL USERS

A total of 53 researchers from 28 industrial firms and 2 government facilities spent a total of 956 days performing research on active proposals during FY 1990. The nonproprietary research projects which had significant activity during this period are briefly summarized.

Aluminum Company of America

Project Title: **Interfacial Properties Characterization in Nicalon SiC Fiber/Alumina-Based Composites** (90-008) *H. Felix Wu*

User Center: MPUC Status: Continuing

During the last visit to ORNL in July and August, measurements on our composites with the nanoindenter failed to debond uncoated or carbon-coated Nicalon SiC fibers in an alumina-based matrix. This might be due to the insufficient load capacity of the indenter or due to the improper sample preparation procedure. Currently, we are working to improve our metallographic sample preparation technique. We now plan to perform additional nanoindentation experiments in the HTML during October. We hope to be able to debond the coated fiber in the ceramic matrix composite sample to provide fiber shear strength and other properties critical to composite design and performance.

Ceramics Process Systems Corporation

Project Title: **Duophase Sialon with Controlled Grain Boundary Phase** (89-052) *Ran-Rong Lee* and *D. L. Ouellette*

User Center: MPUC and XRDUC Status: Continuing

Duophase sialons are currently under development at Ceramics Process Systems Corp. with assistance from the Cookson Company. The preliminary research results on the high-temperature four-point flexural strength at 1000, 1200, 1300, and 1370°C of these new duophase sialons are promising. This material can have strengths as high as 500 MPa at 1200°C and 490 MPa at 1370°C after optimum sintering and annealing. In comparison, the as-sintered material has only a 350 MPa flexural strength at 1300 and 1370°C. Transmission electron microscopy (TEM) and X-ray diffraction show that the crystallization of the grain boundary phase improved the high-temperature mechanical strength of our CM200 material. However, TEM characterization also revealed an inhomogeneous Y-Si-Al-N-O grain boundary phase, which is the factor believed to degrade high-temperature strength and high-temperature oxidation resistance. Further research on grain boundary phase engineering to improve high-temperature properties is proceeding.

Cummins Engine Co., Inc.

Project Title: **Studies of Environmentally Induced Fracture of Diesel Engine Cylinder Head Cap Screws** (90-010) *B. E. Wilde* and *J. E. Bokelman*

User Center: MAUC Status: Continuing

This project was originated to determine the chemical nature of the species contributing to the environmentally induced cracking of Cummins cylinder head capscrews. Near the time that we were scheduled to start the work at HTML, other measurements done by Bryan Wilde and Jim Bokelman of Cummins indicated that temper embrittlement could be a factor influencing the failures. In discussions with staff of the Materials Analysis User Center plus staff at Cummins, it was decided to change the course of the project somewhat to try to determine the cause of the temper embrittlement. Auger examination of an initial sample from a failed capscrew fractured in situ revealed high levels of phosphorus grain boundary contamination. Efforts to confirm this hypothesis with other specimens has been unsuccessful to date, and the research is continuing.

Dow Chemical Company

Project Title: **Determination of the Effect of Experimental Conditions on Lattice and Surface Oxygen Content of the AlN Phase** (89-055) *G. Potter*

User Center: MAUC Status: Continuing

The SIMS instrument was used to conduct measurements, both in the scanning and microprobe modes, to obtain images and spot analyses of AlN. This research is to determine the effect of experimental conditions including sintering agents on the lattice and surface oxygen content of the AlN phase and any second phase present in prepared AlN. The data collected in the HTML are being correlated with the thermal conductivity of the materials to determine the dependence of material performance on both types of oxygen measured. Enough samples were studied to allow quantification of both surface and lattice oxygen in these materials.

EG&G Mound Laboratories

Project Title: **TEM Analysis of Metals in a Lithia-Alumina-Silica Glass Ceramic** (89-043) *W. E. Moddeman*

User Center: MAUC Status: Continuing

In this study, "zerovalent" nickel in lithium aluminosilicate (LAS) glass was characterized with high resolution XPS and with both analytical and ultrahigh resolution TEM. These results were presented at the 1990 American Ceramic Society Meeting (a poster won 2nd prize in its category) and at a Gordon Conference on Glass.

Engelhard Corporation

Project Title: **Evaluation of the Thermal and Hydrothermal Stability of Fluid Cracking Catalyst Materials using High Temperature X-Ray Diffraction Analysis** (90-016) *J. R. St. Amand*

User Center: XRDUC Status: Completed

As fcc catalysts age in the field, aluminum is removed from the zeolite framework, the unit cell contracts and the selectivity of the catalysts is adversely affected. As a result, the amount of non-framework aluminum and Lewis acid sites increases. This in turn increases the amount of coking. Consequently, both changes in phase composition and unit cell size were monitored on three fcc catalyst samples to investigate the degradation of the zeolite component as a function of temperature.

Great Lakes Research

Project Title: **Microstructural Examination of Polished TiB_2-Graphite Samples** (00-003) *E. G. Morris*

User Center: MAUC Status: Continuing

Microprobe analyses were performed to determine the dissolution and migration of TiB_2, and aluminum/cryolite penetration into a TiB_2-graphite composite exposed in an operating commercial hall process aluminum cell for up to 15 months. The objective of this work is to understand TiB_2 degradation mechanisms in order to develop high reliability cathodes for aluminum reduction.

GTE Laboratories, Inc.

Project Title: **Fracture Behavior of PY6 Silicon Nitride Specimens in Tension** (89-050) *A. E. Pasto* and *W. C. VanSchalkwyk*

User Center: MPUC Status: Completed

Tensile strength measurements on a prototype set of ceramic tensile specimens at the HTML resulted in a large number of buttonhead failures, which were traced to an improper value of the buttonhead radius (3.0 mm radii specified, versus 2.5 mm radii provided by the machining laboratories). With these results, we had specimens prepared with a corrected radius, which resulted in a near-zero incidence of buttonhead failures in post-HTML measurements.

Project Title: **High Resolution Interfacial Microstructural Studies of Ceramic Materials** (89-046) *J. Hefter* and *C. Sung*

User Center: MAUC Status: Continuing

The development of advanced toughened silicon nitride composites requires understanding of the relationship between the intergranular second phase and the silicon nitride matrix. Ultrahigh resolution microscopy was found to provide crucial information about the crystallinity and morphology of these phases, specifically when the composites were heat-treated to promote devitrification of the glassy phase. Atomic scale images of the interfaces between the silicon nitride matrix and the intergranular phase as well as images of the crystallized phases, their twin-like structure as well as other important crystallographic defects were provided and are being related to mechanical property data.

Institute for Defense Analyses

Project Title: **High Temperature Testing of Ceramic Fibers** (89-011) *W. S. Hong, J. M. Sater* and *M. A. Rigdon*

User Center: MPUC Status: Completed

The purpose of this research was to systematically assess the effects of varying certain test parameters such as strain rate and thermal history on the measured high-temperature tensile strength and elastic modulus of a specific ceramic fiber, SCS-6, which has been used by many researchers for reinforcing ceramic and metal matrix composites. We have chosen the SCS-6 silicon carbide fiber from Textron Specialty Materials, and used the unique hot fiber strength measuring capability recently developed at the HTML. Fiber strength measurements were made at 1000° C and 1200° C, with two pretest soak times at temperature (3 min and 30 min) and two strain rates (0.2%/min and 2.0%/min, based on a gripped gage length of 155 mm). Initial results indicate that, for these fibers, changing the strain rate at 1200° C has had virtually no effect on ultimate tensile strength. At 1000° C, the measured average strengths increase as expected when using faster strain rates, indicating perhaps that a stress corrosion process was operative. At both temperatures, lower strengths were observed with increased soak times.

McDonnell Douglas

Project Title: **Effects of Processing Conditions on the Thermophysical Properties of Carbon-Carbon Composites** (90-002) *J. W. Sapp* and *D. A. Bowers*

User Center: PPUC Status: Continuing

Utilizing the instruments in the Physical Properties User Center, data were collected to correlate the effects of processing conditions on the thermophysical properties of carbon-carbon composites. Four different carbon-carbon composite samples were used in measurements in an inert atmosphere to determine the following: thermal diffusivity, 200-1700° C; thermal expansion, 20-1450° C; and specific heat, 200-1200° C.

Thermacore, Inc.

Project Title: **Refractory Metal Heat Pipe Compatibility with Lithium at Elevated Temperatures** (89-007) *J. R. Hartenstine*

User Center: MAUC Status: Completed

The purpose of the research was to evaluate refractory metal heat pipe compatibility with lithium at elevated temperatures. A series of tantalum heat pipes were fabricated using lithium as the working fluid. These heat pipes were operated at 1150°C for 1000 h. The heat pipes were subsequently sectioned and the tantalum envelope material was analyzed in the HTML user centers.

The analyses were performed utilizing the JEOL 733 electron microprobe. No significant corrosion of the tantalum envelope material was evident during the inspection of the evaporator and condenser sections. The results from the HTML effort indicated that the procedures and processes used to fabricate the tantalum/lithium heat pipes is capable of producing very long life refractory metal heat pipe.

United Technologies Research Center

Project Title: **Effects of Aging Time and Temperature on the Thermal Conductivity of Plasma Sprayed Zirconia and Mullite for Thermal Barrier Coating Applications** (90-009) *J. R. VanValzah* and *H. E. Eaton*

User Center: PPUC Status: Continuing

The thermal conductivities of 30 plasma-sprayed zirconia and three mullite specimens were measured in the as-sprayed and thermally aged conditions. The zirconia aging matrix consisted of isothermal exposures at temperatures between 870°C and 1500°C for times ranging from 1 to 500 h. Conductivity was determined for each specimen over a range of temperatures between 200 and 1300°C. In addition, the effects of porosity type and level in the zirconia were examined. Mullite aging conditions were 870°C/100 h and 540°C/500 h. Results obtained to date show large increases in thermal conductivity due to aging with aging temperature being much more significant than aging time. Additionally, increasing the porosity level is, as expected, associated with a reduction in the thermal conductivity.

Universal Energy Systems, Inc.

Project Title: **Characterization of the Oxide/Corrosion Scales on Three Classes of Iron Based Alloys** (89-041) *V. Srinivasan*

User Center: MAUC and MPUC Status: Completed

Oxide/corrosion scales were characterized at the HTML user facility using the scanning Auger spectrometer (SAM), electron spectroscopy for chemical analysis/secondary ion mass spectroscopy (ESCA/SIMS) and the nanoindenter. Corrosion scales were thermally grown under different exposure conditions that were typical of coal gasification/combustion. The experimental alloys were high purity austenitic and ferritic steels with and without microconstituent additions. The results indicate factors that enhance the protectiveness of thermally grown chromia scales in the presence of sulfur. Protective scales, according to the results of nanoindenter experiments, have lower stiffness (lower Young's modulus). This research is directed to advanced coal conversion systems.

Project Title: **Study of Surface Modification and Coatings of SiC and Si_3N_4 at High Temperatures** (89-018) *R. S. Bhattacharya*

User Center: MPUC Status: Continuing

The research involved co-implantation of Ti^+ and C^+, and Cr^+ and C^+ into sintered SiC and hot- pressed Si_3N_4. Diffusion of dopants, recrystallization of the implanted layers, and formation of second phases upon annealing at high temperature were investigated. The purpose is to determine if precipitates of TiC and Cr_3C_2 could be formed in the near surface region of SiC and Si_3N_4, and if the precipitate formation can help improve the surface hardness and toughness of these structural ceramics.

U. S. Bureau of Mines

Project Title: **Microstructure and Chemistry of Specific Regions of a Fine Grain SiC Specimen Subjected to Laser Irradiation** (90-011) *L. Y. Sadler*

User Center: MAUC Status: Continuing

Fracture surfaces were studied using both the scanning electron microscope and optical microscopy. Excellent quality micrographs were taken of various regions of SiC powder compacts representing processing temperatures ranging from room temperature to in excess of 2000°C, and analyses of these structures are continuing.

UNIVERSITY USERS

A total of 40 researchers from 19 universities spent a total of 607 days performing research on 43 active proposals. A brief summary of each nonproprietary proposal which had significant activity during this report period is given below.

Alfred University

Project Title: **Establishment of the Peritectic Reaction Sequence for the Bi-Sr-Ca-Cu-O Superconductors** (90-032) *D. P. Matheis* and *R. L. Snyder*

User Center: PPUC and XRDUC Status: Continuing

Research to date on this project in the HTML included high-temperature X-ray diffraction analysis as well as differential scanning calorimetry (DSC) analysis of melt-quenched samples of stoichiometric and non-stoichiometric $Bi_2Sr_2CaCu_2O_8$ powders. The analysis is aimed at investigating the crystallization and peritectic melting reactions of these candidate superconducting materials.

Clemson University

Project Title: **Study of the Character of Stresses Developed in an Iron Based Alloy Subject to Sulfidizing Mixed Gases at Elevated Temperatures** (87-013) *J. S. Wolf*

User Center: XRDUC Status: Continuing

The primary objective of this research has been to provide some means for estimating the protective quality of scales formed in various aggressive atmospheres of interest at elevated temperatures. The crystalline nature of these scales, their microstructural evolution, and the stresses generated during corrosion were studied. One purpose of this research is to understand how the oxidation and corrosion resistance of the steels could be improved. For these tasks, much of the data collection and processing was done utilizing the X-ray Diffraction Facility of the HTML.

Project Title: **Stress Generation In and Structure Of Scales Developed on Unalloyed Nickel** (88-030) *J. S. Wolf*

User Center: XRDUC Status: Continuing

This research has been directed toward the characterization of ceramic oxide scales naturally formed upon unalloyed nickel in oxygen at high temperatures. The primary objective of this research has been to investigate methods for estimating the growth stresses which occur in such oxides. The crystalline nature of these scales and the stresses generated during oxidation were the primary topics of investigation. For these tasks, much of the data collection and processing was done utilizing the high-temperature X-ray diffraction facility of the HTML.

Project Title: **High Temperature X-Ray Analysis of Titanium Aluminides** (88-034) *H. J. Rack, P. K. Chaudhury* and *M. G. Long*

User Center: XRDUC Status: Continuing

High-temperature phase stability for Ti-Al-Nb (Ti-24Al-11Nb and Ti-25Al-10Nb-3V-1Mo) and gamma-Ti-Al-V alloys has been completed. The results are presently being correlated with DTA/DSC and transmission electron microscopy efforts under way at Clemson for publication.

Georgia Institute of Technology

Project Title: **Study of AlN-BN Composites** (88-031) *J. A. Hanigofsky*

User Center: MAUC Status: Completed

Completed transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) analysis on seven specimens of AlN + BN coatings deposited on Al_2O_3. The measurement and analysis time included about 3 weeks actual time at the HTML. Microstructural and elemental analyses were used to identify interfacial structures and elemental interdiffusion between the major phases.

Project Title: **Moire Interferometry on Specimens of Lucalox Alumina Ceramics to Directly Measure Microstrains in Specimens** (89-025) *J. S. Epstein* and *G. B. May*

User Center: MPUC Status: Continuing

Extensive consultation has taken place between J. S. Epstein of Georgia Tech and M. Jenkins of the HTML on conversion of one of the Instron tension systems from strain to displacement control as well as selection of the correct specimen geometry and institutional requirements for fabricating the required Lucalox tension specimens. Preparation of the required specimens has been initiated.

Project Title: **Study of the Concentration Profile in a Diffusion Couple after a Diffusion Anneal** (90-022) *T. H. Sanders* and *H. R. Last*

User Center: MAUC Status: Continuing

Electron microprobe measurements have been used to determine the composition profile in several diffusion-annealed couples. The diffusion couples investigated contain an Al-Cu or an Al-Mg alloy coupled with either an Al-Zr or an Al-Mn alloy. This information on the development of the concentration profile is being used with further diffusion experiments for the determination of diffusion parameters such as the activation energy for diffusion and the pre-exponential constant D_O for selected alloying elements. Also, this information will be used in conjunction with results obtained from annealing experiments performed on the couples to study precipitation as a function of alloy composition.

North Carolina State University

Project Title: **Hard Carbon Coating on Silicon** (90-014) *J. Park*

User Center: MPUC Status: Continuing

The objective of this project is to investigate the hardness of diamondlike-carbon (DLC) films on silicon obtained by the laser ablation and deposition technique. Microhardness measurements have been performed on the samples using the nanoindenter. The samples were prepared with different substrate temperatures or with hydrogen content. More extensive experimental work is planned on hydrogenated DLC films.

New Mexico Institute of Technology

Project Title: **Effect of Tin Dioxide Interlayer in Alumina/Glass Composites** (88-029) *K. K. Chawla*

User Center: MAUC and MPUC Status: Continuing

The objective of this project is to investigate the interface characteristics in composites in the system alumina/glass. Specifically, we wish to tailor the interface to obtain an enhanced fracture toughness. The alumina/glass system forms a very strong chemical bond, resulting in low fracture toughness. The interface characteristics can be changed by incorporating an interphase layer of tin dioxide between alumina and glass. The interphase layer acts as a diffusion barrier between the alumina and the glass, thereby inhibiting the chemical reaction and providing a weak layer and conditions highly favorable for fiber pullout, thus contributing to a high fracture toughness.

The work at HTML involves nanoindenter studies on alumina/glass and alumina/tin dioxide/glass systems, transmission electron microscopy (TEM) and secondary ion mass spectroscopy (SIMS) characterization, and high-temperature flexure strength measurements of these composites.

University of California at Los Angeles

Project Title: **XPS Study of Quartz Dissolution Surfaces** (89-062) *A. Gratz*

User Center: MAUC Status: Completed

Quartz etched in hydroxide solutions were studied by X-ray photoelectron spectroscopy to determine the extent of cation binding to and the effect of dissolution on the surface. The surface was found to consist of a precipitated layer of adventitious carbon, cations from solution, and Si and O, deposited on an SiO_2 substrate. Cations above the substrate were readily exchanged and not concentrated at the substrate-deposit interface. We conclude that cations did not bind strongly to the substrate. Shifts in binding energy of O and Si were limited to the deposited layer, indicating poly ordered coating and an undisturbed substrate.

University of Denver

Project Title: **Residual Stresses and Thermal Cycling in Ceramic Composites** (89-030) *B. L. Ballard* and *P. K. Predecki*

User Center: XRDUC Status: Continuing

The goal of this research project is to characterize the residual stress states found in a ceramic matrix composite consisting of alumina reinforced with silicon carbide whiskers (Al_2O_3/25 wt% β-SiC_w) composite at elevated temperatures. Measurements using the HTML's X-ray diffractometer with its accompanying specimen heating furnace were used to characterize Bragg angle displacements in both phases of the specimen over a 25-1250° C temperature range. Also, values for the lattice thermal expansion of β-SiC_w over these temperatures were obtained during the course of the research. Results from the measurements are being analyzed.

University of Florida

Project Title: **Characterization and Testing of Ceramic Oxide Fibers** (89-009) *F. Feller, III A. A. Morrone* and *S. M. Sim*

User Center: MAUC and MPUC Status: Continuing

Short, nonuniform fibers of ZrO_2/Al_2O_3 and mullite have been synthesized. These have been analyzed at the HTML using the JEOL 2000FX analytical transmission electron microscope. We are developing continuous and uniform fibers of the same compositions. When these fibers are prepared, we plan to perform direct strength measurements on these fibers in the unique fiber strength facility in the HTML.

University of Illinois

Project Title: **Effects of High Intensity Laser-Pulse-Generated Shock Waves on the Microstructures and Mechanical/Physical Properties of Metals** (89-069) *J. M. Rigsbee* and *J. P. Chu*

User Center: MPUC and PPUC Status: Continuing

The nanoindenter in the Mechanical Properties User Center was used to analyze the strength and deformation characteristics as a function of depth away from the shocked surface of materials. The materials studied were single-phase ferritic (pure iron - polycrystalline and single crystals) and austenitic (types 304L and 316 stainless steel) iron-based alloys. Data obtained to date are being analyzed and look very promising.

Project Title: **Analysis of Modified Fibers and Composites in Nicalon SiC Fiber/MDF Cement-Polymer System** (88-038) *D. M. Hansen* and *A. J. Burreson*

User Center: MPUC Status: Completed

The nanoindenter was used to perform indentation tests on Nicalon SiC fiber reinforced calcium aluminate DSP cement composites. These tests were to examine the effects of different fiber surface treatments on the interfacial shear strength.

University of Michigan

Project Title: **Study of Sintered Silicon Nitride/Silicon Carbide Composites and the Interface Structure Between the Silicon Nitride Matrix and the Silicon Carbide Whiskers** (87-006) *T-Y. Tien* and *S. D. Nunn*

User Center: MAUC Status: Completed

Microstructural evaluation of SiC whisker reinforced Si_3N_4 composites was conducted using the JEOL 2000FX transmission electron microscope. The composition and morphology of the matrix, the whiskers, and the sintering aid additive which forms an interfacial layer at the grain boundaries was evaluated. Energy dispersive spectroscopy (EDS) analysis showed solid solution formation in the matrix (β'-Si_3N_4) and the intergranular phase (yttrium aluminum garnet). Crystallization of the grain boundary phase was confirmed by selected area diffraction. An unexpected finding was the observation of amorphous particles of the sintering aid material within Si_3N_4 grains, apparently entrapped during crystallization of the βSi_3N_4 grains from the liquid.

University of New Mexico

Project Title: **Structure and Reactivity of Metal Particles supported on Model Oxide Surfaces** (88-002) *A. K. Datye*

User Center: MAUC Status: Continuing

This research is focused on understanding the interfacial structure between metals and oxide superconductors on the atomic level. The nature of Ag/1-2-3 superconductor interfaces in powders grown by aerosol decomposition was examined. In the future, we expect to devote more time to the analysis and simulation of high resolution transmission electron microscopy images derived from metal/ceramic interfaces from these model systems.

Project Title: **Characterization of Polymer-Derived Ceramic Materials** (88-003) *A. K. Datye*

User Center: MAUC Status: Continuing:

The atomic structure of the BN/MgO interface has been successfully imaged. The results show that the interplanar spacing in the BN layers close to the interface is affected by the proximity of the MgO. The spacing between the BN sheets and MgO was found to be 3.5 A suggesting either Van der Waal's type interaction or a bridging oxygen that serves to bind these two ceramic materials. Such information is vital to understanding the origins of macroscopic phenomena such as interfacial strength at the atomic scale.

During this reporting period, we also completed a study of the oxidative stability of BN coatings on MgO. While BN is stable up to 600° C in air, at higher temperature it is oxidized and reacts with MgO to form $Mg_2B_2O_5$.

University of Tennessee

Project Title: **Study of Alumina/Metal and Metal/Molybdenum Carbide Interfaces Prepared via Excimer Laser and Sputter Deposition Techniques** (87-016) *A. J. Pedraza* and *M. J. Godbole*

User Center: MAUC Status: Continuing

The interface of a copper-sapphire couple that was irradiated with a nanosecond pulsed-excimer laser was studied by transmission electron microscopy. Deposited layers of 30 or 100 nm thickness were laser treated in an argon-4 vol % hydrogen atmosphere with energy densities in the range of 0.5-0.75 J/cm^2. The copper film and a thin alumina layer were melted by the laser pulse. Two well-differentiated regions could be observed in the modified layer. The region closer to the unmodified substrate consisted of epitaxially regrown alumina with crystallites misoriented up to 10° relative to the substrate sapphire orientation, while precipitate particles could be seen closer to the resolidified copper. The precipitate compound exhibited a hexagonal structure closely related to sapphire where copper substituted for some aluminum. These observations are in agreement with a previously developed mathematical model that predicts melting of a thin substrate layer. These results strongly suggest that the observed three- to four-fold increase in adhesion in copper-sapphire couples is due to the presence of an intermediate compound.

VPI & SU

Project Title: **Characterization of Bulk Hydrogen Concentrations and Hydrogen Concentration Profiles in Aluminum-Lithium Alloys** (90-012) R. E. Swanson and F. C. Rivet

User Center: MAUC Status: Completed

Various electrochemical charging techniques were used to produce internal hydrogen in several Al-Li alloys. The goal was to evaluate the role of hydrogen in the plastic deformation and low temperature mechanical behavior of these alloys. It was desired to produce internal hydrogen, at known levels, without inducing surface damage, which would lead to stress risers and spurious mechanical test results. The SIMS instrument was used to provide semi-quantitative results which showed that charging with either of the two methods listed below provided sufficient hydrogen. In support of this work, a noncontact optical profilometer showed that these charging methods produced essentially no surface damage.

Galvanostatic in 0.04 N HCl + As_2O_3 in deionized water at -500 microA for 20 h
Potentiostatic in same solution at -3V for 5 h

These results are significant in that they demonstrate that internal hydrogen can indeed be produced in these alloys without surface damage other investigators have experienced.

Project Title: **Measurement of Boron Content of Intergranular Fracture Facets of a Boron-Doped Ni_3Al Alloy** (90-001) *Y-C. Lin*

User Center: MAUC Status: Continuing

A sample of boron-doped Ni_3Al having the configuration for fracture in the Auger spectrometer in the Materials Analysis User Center was prepared. The surfaces were metallographically polished and etched, and electron channeling patterns from about 40 grains in the vicinity of the notch, across which fracture would occur, were obtained using a scanning electron microscope at the University of Tennessee. This sample was then hydrogen charged to enhance grain boundary fracture, and immediately placed in the Auger spectrometer, and fractured within about 30 min. The boron content of about 20 grain boundary fracture facets at the edges for which channeling patterns were obtained was measured. We are now determining the relative misorientation of the pairs of grains through which the fracture propagated and this will be correlated with the B content.

Project Title: **Examination of the Chemistry of the Microstructures of Weld Samples of Hastelloy B2** (90-020) *C. R. Brooks*

User Center: MAUC Status: Continuing

Welds of the Ni-Mo alloy Hastelloy B2 in components of a coal gasification plant have shown intergranular corrosion. We are in the process of examining samples of these welds with secondary ion mass spectroscopy (SIMS) in the HTML to identify the fine grain boundary particles. The work is still in an early stage.

Project Title: **Analysis of the Fracture Surfaces of Samples of a High-Temperature Flange Bolt Material** (89-024) *C. R. Brooks*

User Center: MAUC Status: Continuing

A metallographic sample of a 12% Cr embrittled flange bolt has been examined with secondary ion mass spectroscopy (SIMS) in the HTML. Particles rich in carbon and chromium have been identified in the prior austenite grain boundaries. Fracture surfaces are being examined.

Project Title: **Study of the Fracture Surfaces of Ni-20 at. % Mo Alloys Which Have Been Microalloyed with Various Elements** (89-023) *C. R. Brooks*

User Center: MAUC Status: Continuing

A Ni-20 at. % Mo alloy containing a microalloying level of boron was prepared. A sample of this alloy was solution-annealed, quenched to retain the alpha phase, then aged for 1 h at 775°C. This treatment causes ordering and strengthening, but normally the alloy is brittle, fracturing along the former alpha phase high angle grain boundaries. The microalloying was an attempt to ductilize the alloy in the ordered condition, and the sample showed some ductility in a standard bend test. A sample of this alloy was fractured in the Auger spectrometer, and the fracture surfaces analyzed for boron. None was detected, indicating that essentially no boron

segregation occurred at the grain boundaries as a result of the thermal treatment. In this case, it appears that boron segregation to the grain boundaries is not the cause of the observed ductility. A paper on this work is being prepared.

Project Title: **Research in Support of a Laser Welding Study on Inconel 718** (89-017)
N. B. Dahotre, M. H. McCay and *T. D. McCay*

User Center: PPUC Status: Completed

To accurately model the effects of laser pulse welding on crack sensitivity, certain physical properties of the high-temperature alloy Inconel 718 are required. Among these are the heating and cooling transformation temperatures for liquid and solid phases. Differential scanning calorimetry (DSC) and scanning thermal analysis (STA) were used to determine temperature zones for different transformations in wrought as well as cast Inconel 718. The samples were subjected to heating and cooling cycles with rates of 10 and 40° C/min in the temperature range 40-1350° C. The solidus temperature is about 1200° C and the alloy becomes completely liquid at about 1275° C. At about 1170° C a high-temperature phase formation occurs by solid state transformation which is not observed during cooling. A significant deviation in the base line slope by a factor of two in the DSC analysis in the temperature range 570-870° C indicated the presence of low-temperature phases.

Project Title: **Study of Interfacial Reaction Phases in Laser Welded Ceramic Particulate/Al-alloy Metal Matrix Composite** (89-056) *N. B. Dahotre* and *S. C. Gopinathan*

User Center: MAUC and XRDUC Status: Continuing

The microstructural changes in the laser processed A356 Al alloy matrix composites reinforced with 10 and 20 vol % SiC particulates were characterized. The microstructure of the laser melted region was investigated using transmission electron microscopy and X-ray microchemical analysis techniques. Laser processing produced partial or complete dissolution of SiC particles and sometimes resulted in the formation of aluminum carbide. The associated rapid cooling also produced a fine distribution of nonequilibrium complex precipitates. In addition, the laser energy modified the SiC surface both physically and chemically. This research is continuing.

Project Title: **Analysis of High Temperature Phase Transformation in Inconel 718** (89-057)
N. B. Dahotre, M. H. McCay and *T. D. McCay*

User Center: XRDUC Status: Completed

X-ray diffractometry data were obtained on Inconel 718 in the form of as-received cast, as-received wrought, and grain-growth wrought samples at room temperature using the HTML X-ray diffraction instruments. The X-ray diffraction data were also collected from the same samples at discrete temperatures (for as-received: 530, 580, 620, 720, 770 and 820° C; for as-received wrought: 540, 570, 600, 730, 760° C; and for wrought grain-grown: 590, 630, 730, 770, 800° C) by scanning them through 20 to 120° at 0.5°/min. In order to avoid surface oxidation effects, the high-temperature furnace was filled with argon during these experiments. Following the high-temperature runs, the room-temperature X-ray scans were run on the same sample to enable detection of irreversible transformation products as well as the disappearance of the reversible transformation products.

Vanderbilt University

Project Title: **Wear Behavior of Cu-Al Solid Solution Alloys** (89-047) *R. A. Poggie* and *J. J. Wert*

User Center: MAUC Status: Continuing

The wear properties of Cu-Al alloys and the chemical bonding of selected elements on wear surfaces are major objectives of this research. A large body of data has been collected using x-ray photoelectron spectroscopy analyses of three copper-aluminum solid solution alloys (1, 4, and 6 wt % Al in Cu). The Cu-Al alloys surfaces analyzed to date were in the as-polished condition, ion- sputtered condition, and surfaces oxidized at ambient temperature. It is planned that further analyses of worn Cu-Al surfaces will be performed before the end of CY 1990.

Project Title: **Examination of Sapphire Substrate Surfaces** (90-030) *J. J. Wert* and *J. E. Pawel*

User Center: MAUC Status: Continuing

Our first training session on the Hitachi S-800 field emission scanning electron microscope in the HTML was completed on August 15, 1990. An as-deposited Fe (100 nm)/Al_2O_3 specimen with five pull test sites was examined using a 2.5-kV electron beam. Even at this low voltage, however, the charging of the substrate in the regions where the film had been removed (the regions of interest in this investigation) obscured the details of the film failure sites, and means to overcome this experimental difficulty are still being studied.

Virginia Polytechnic Institute & State University

Project Title: **Study of the Phase Transitions of Crystalline Aluminophosphates** (89-054) *D. Young* and *M. J. Annen*

User Center: XRDUC Status: Completed

In situ X-ray diffraction was used to study the transition of experimental aluminophosphates at elevated temperatures. In addition, changes in the hexagonal lattice of one of the materials designated as VPI-5 under various conditions of temperature, pressure, and humidity were determined.

Project Title: **Measurement of Lattice Parameters as a Function of Temperature on Sodium Zirconium Phosphate** (89-061) *S. M. Van Aken*

User Center: XRDUC and PPUC Status: Completed

The high-temperature X-ray diffraction unit was used to conduct research on sodium zirconium phosphate. The information gathered will be used to develop new high-temperature thermal shock resistant materials for use in heat engines. Laser flash thermal diffusivity measurements have begun.

APPENDIX A

HTML PHYSICAL FACILITIES AND PERSONNEL

The Director of the HTML User Program is Dr. V. J. Tennery, who is also a section head in the Metals and Ceramics Division, parent organization of the HTML. Dr. Tennery is Chairman of the User Advisory Committee which is responsible for review of the research proposals from university and industrial users.

The administrative support staff and their functions are

Ms. Felicia Foust, User Coordinator
Ms. Donna Conger, secretarial responsibilities, User Program
Ms. Pam Rice, secretarial responsibilities, User Staff
Ms. Robin Martin, secretarial assistance

A description of the function of each of the four user centers in the HTML is given here. The User Centers' staff are listed also.

MATERIALS ANALYSIS USER CENTER (MAUC)

The materials characterization performed in the MAUC includes microstructural analyses and chemical and morphological characterization of surfaces utilizing sophisticated state-of-the-art instruments, generally not available to the user at the home institution.

The Group Leader of the MAUC is Mr. T. A. Nolan. Other staff and their equipment expertise are

Dr. L. F. (Larry) Allard, JEOL 4000EX (TEM) and JEOL 2000FX (AEM)
Dr. A. (Ashok) Choudhury, VG ESCA/SIMSLAB2 and Auger
Ms. D. W. (Dorothy) Coffey, Hitachi S-800 (FE-SEM) and sample preparation
Mr. L. A. (Larry) Harris, VG ESCA/SIMSLAB2
Mr. T. J. (Tommy) Henson, JEOL 733 Electron Microprobe
Ms. K. L. (Karren) More, JEOL 2000FX (AEM) and JEOL 4000EX (TEM)
Mr. T. A. (Tad) Dodson, computer services support

MECHANICAL PROPERTIES USER CENTER (MPUC)

The MPUC is dedicated to the study of high-temperature mechanical properties of structural ceramics and alloys, including silicon carbides, silicon nitrides, aluminum oxide, transformation toughened zirconia, and high-temperature alloys such as superalloys. Facilities are available for the measurement of strength and toughness as a function of time, temperature, and stressing conditions. In addition to standard flexure strength measurements, the MPUC has 12 state-of-the-art tensile systems capable of evaluating the tensile strength of monolithic and ceramic matrix composites to temperatures up to 1600°C. New instrumentation includes the ability to study the tensile properties of single fibers to 1500°C and to directly measure the tensile deformation and fracture of continuous fiber-reinforced composites at high temperatures.

The Group Leader of the MPUC is Dr. M. K. Ferber. Other staff and their equipment expertise are

Dr. M. G. (Michael) Jenkins, tensile and flexure test facilities
Mr. V. T. (Tyler) Jenkins, ceramic specimen preparation
Mr. R. L. (Ralph) Martin, Universal test machines and sample preparation
Ms. R. L. (Becky) Freeny, Nanoindenter

PHYSICAL PROPERTIES (PPUC) AND X-RAY DIFFRACTION USER CENTERS (XRDUC)

The PPUC is organized to include instruments for determination of a broad range of the thermal physical properties of solid materials. Facilities are operational for the measurement of thermal diffusivity, specific heat, bulk thermal expansion, differential thermal analysis/thermal gravimetric analysis/mass spectra, and differential scanning calorimetry. Thermal diffusivity can be measured to 2000°C, and the other instruments operate to 1450°C. Efforts have begun to expand the modeling and measurement of thermal transport in materials.

X-ray diffraction is used to study anisotropic thermal expansion, phase equilibria, and microstructural defects of materials at either elevated temperatures or room temperature. The high-temperature X-ray diffraction furnace is capable of operation to 1600°C in air or other environments and to 2700°C in vacuum. Extensive data processing facilities and gas environment control capabilities are being developed.

The Group Leader of both the PPUC and the XRDUC is Dr. C. R. Hubbard. Other staff and their equipment expertise are

Mr. O. B. (Burl) Cavin, all X-ray equipment
Dr. R. B. (Ralph) Dinwiddie, laser flash diffusivity
Mr. W. D. (Wally) Porter, STA, DSC, Dilatometer

RESIDUAL STRESS USER CENTER

This new Center will be managed by Dr. C. R. Hubbard. It will provide sophisticated instruments for measurement of residual stress in and near the surface of ceramics and alloys. In many systems, these stresses are known to be critical to the reliability of the material in advanced applications. Specifications for a high flux X-ray generator and stress/texture goniometer system have been written and submitted for purchase. Plans are to have the X-ray part of this Center available to users by the latter part of FY 1991. A neutron diffraction residual stress facility is planned for a later time. It will be located at the High Flux Isotope Reactor and is planned for availability during the latter part of FY 1993, depending on the status of funding. The neutron facility will complement the X-ray facility by providing means for making stress measurements within the volume of advanced materials, and will be the first such dedicated facility in the United States.

CERAMIC SPECIMEN PREPARATION USER CENTER

This new Center will be managed by Dr. M. K. Ferber. Specifications for the equipment have been submitted to purchasing. Some equipment is available and is located in two labs on the second floor in the core area. This center will provide an extensive capability for users to perform material finishing research plus conduct a number of highly accurate dimensional measurements with, for example, profilometers and high magnification comparators. Extensive computer control of the instruments is planned, including dimensional data acquisition and reduction. Two additional laboratory modules in the HTML were acquired for this new center.

APPENDIX B

LISTING OF THE ADVISORY COMMITTEES

HTML Advisory Committee Members

	Term Expires
Dr. Maxine L. Savitz, Director Ceramic Components Division Garrett Processing Company 19800 South Van Ness Ave. Torrance, California 90509	1993
Mr. Woodie Howe Coors Technical Ceramic Company 1100 Commerce Park Drive Oak Ridge, Tennessee 37830	1992
Professor John J. Hren Head, Materials Science and Engineering North Carolina State University Box 7907, Yarborough Drive Raleigh, North Carolina 27695-7907	1992
Dr. Joseph N. Panzarino Norton Company Advanced Ceramics Division Goddard Road Northboro, Massachusetts 01532	1991
Dr. James W. Patten Director, Materials Engineering Cummins Engine Company 500 Jackson Street Columbus, Indiana 47201	1991

HTML User Advisory Committee Members

Dr. V. J. Tennery, Director of the HTML, is permanent Chairman of this Committee.

	Term Expires
Dr. J. C. Danko, Director Center for Materials Processing The University of Tennessee 101 Perkins Hall Knoxville, Tennessee 37996-2000	1992
Mr. Lance Groseclose Allison Gas Turbine Operations General Motors Corporation Post Office Box 420 Indianapolis, Indiana 46206-0420	1992
Dr. Arvid Pasto GTE Laboratories, Inc. 40 Sylvan Road Waltham, Massachusetts 02254	1991
Ms. M. J. Rohr Oak Ridge Operations Office U.S. Department of Energy Oak Ridge, Tennessee 37831	1991
Dr. Linda Horton Metals and Ceramics Division Oak Ridge National Laboratory P. O. Box 2008 Oak Ridge, Tennessee 37831	1990

APPENDIX C

HTML CUMULATIVE USER EXPERIENCE

Figure C.1 illustrates the cumulative user days for industry, university, and local users in the HTML User Program for the entire 13 quarters of operation to date. Approximately 61% of the users have been local researchers, while about 25% have been from industry and 14% have been from universities.

ORNL-DWG 90-17127

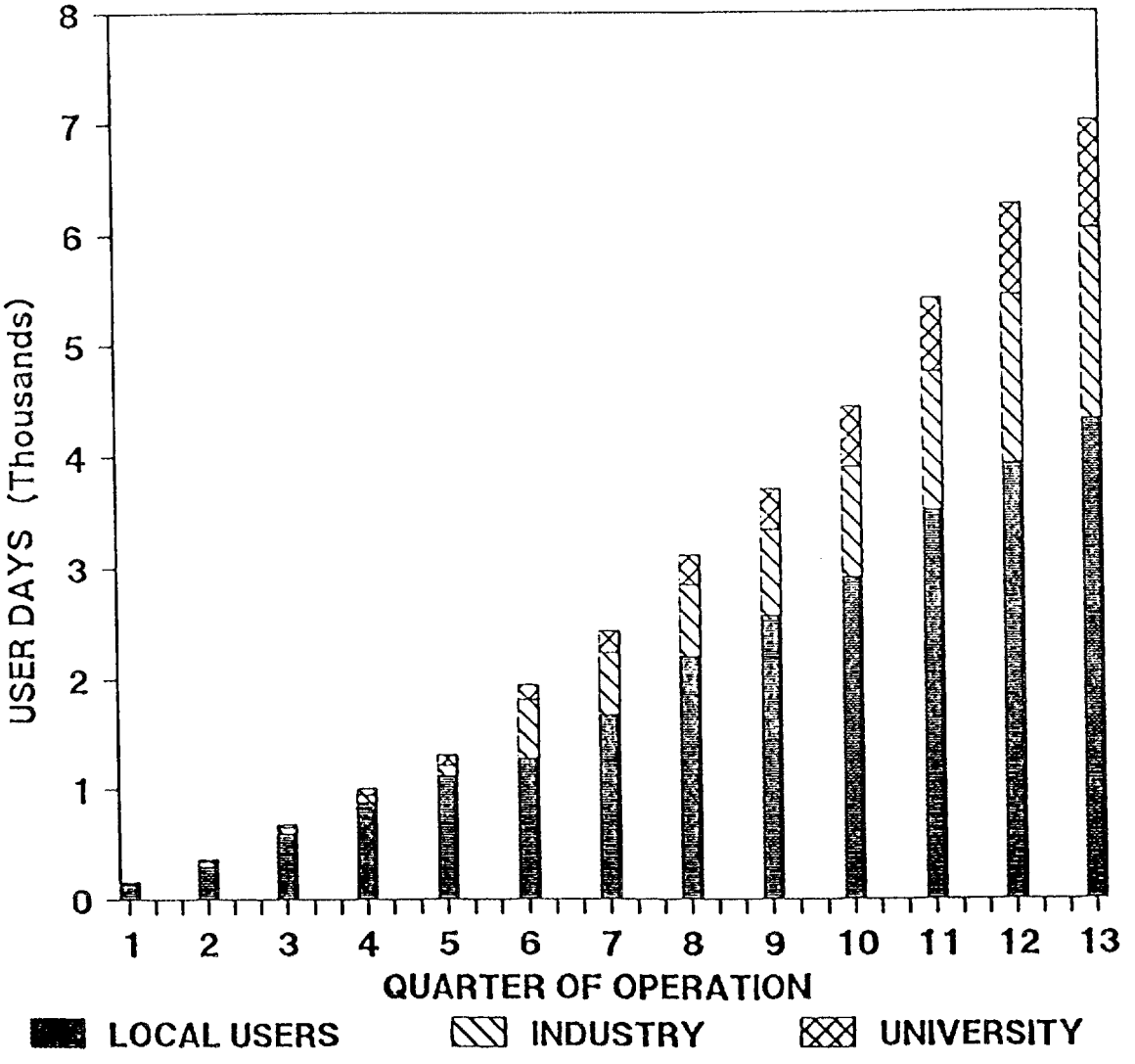


Fig. C.1. HTML cumulative user days from start of User Program.

APPENDIX D

PUBLICATIONS AND PRESENTATIONS

User Center Staff are indicated by an underline. The User's home institution is listed at the end of the citation. These publications are in the order of the name of the User Institution.

INDUSTRY USERS PUBLICATIONS

K. R. Selkregg, K. L. More, S. G. Seshadri and C. H. McMurtry, "Microstructural Characterization of Silicon Nitride Ceramics Processed by Pressureless Sintering, Overpressure Sintering, and Sinter/HIP," Ceramic Engineering & Science Proceedings, L. G. Schioler, ed. 11 (7-8), p. 603 (1990), American Ceramic Society. CARBORUNDUM

M. V. Parish and J. D. Hodge, and C. R. Hubbard, "Thermal and Phase Analysis of $YBa_2Cu_3O_{7-x}$ Powder Compacts with Organic Acid Additives," *Proceedings of the Third International Conference on Ceramic Powder Processing Science*, San Diego, CA, February 4-7, 1990; (1990). CERAMICS PROCESS SUPERCONDUCTOR

Ran-Rong Lee and Wen-Cheng Wei, "Fabrication, Microstructure and Properties of SiC-A/N Ceramic Alloys," Ceramic Engineering & Science Proceedings, 11(7-8), p. 1094 (1990), American Ceramic Society. CERAMICS PROCESS SYSTEMS

R. T. Cassidy, W. E. Moddeman, L. F. Allard, "The Use of Austenitic Stainless Steels in Pyrotechnic Devices," *Journal of Metals*, in press. EG&G MOUND LABORATORIES

W. E. Moddeman, R. T. Cassidy, J. C. Birkbeck, and L. F. Allard, "TEM and Auger Examinations of the Oxide Film on an Al-Containing Austenitic Stainless Steel," *Journal of Metals*, in press. EG&G MOUND LABORATORIES

INDUSTRY USERS PRESENTATIONS

T. A. Nolan, L. F. Allard, and M. H. Rawlins, "The Structure of Interfaces Resulting from Whisker Surface Pretreatments in SiC Whisker-Reinforced Ceramic Matrix Composites," MRS Fall Meeting 1989, Boston, MA, December 2-5, 1989. AMERICAN MATRIX, INC.

T. A. Nolan, L. F. Allard, D. W. Coffey, M. H. Rawlins, and R. W. Nixdorf, "Microstructural Characterization of a New VLS TiN Whisker Product," 14th Annual Conference on Composites and Advanced Ceramics, Cocoa Beach, FL, January 14-17, 1990. AMERICAN MATRIX, INC. First Prize in Poster Session

L. J. Klemptner, J. D. Hodge, O. B. Cavin, and C. R. Hubbard, "Phase Formation of Yttrium Barium Cuprates," Third International Conference on Ceramic Powder Processing Science, San Diego, February 4-7, 1990. CERAMICS PROCESS SUPERCONDUCTOR

M. V. Parish and J. D. Hodge, and C. R. Hubbard, "Thermal and Phase Analysis of $YBa_2Cu_3O_{7-x}$ Powder Compacts with Organic Acid Additives," Third International Conference on Ceramic Powder Processing Science, San Diego, CA, February 4-7, 1990. CERAMICS PROCESS SUPERCONDUCTOR

J. D. Hodge and L. J. Klemptner, and C. R. Hubbard, "Phase Formation of Yttrium Barium Cuprates," annual meeting, American Ceramic Society, Dallas (1990). CERAMICS PROCESS SUPERCONDUCTOR

Ran-Rong Lee and Wen-Cheng Wei, "Fabrication, Microstructure and Properties of SiC-AlN Ceramic Alloys," 14th Annual Conference on Composites and Advanced Ceramics, January 14-17, 1990. CERAMICS PROCESS SYSTEMS

G. E. Potter, A. K. Knudsen, A. C. Choudhury, and J. C. Tou, "Characterization of Aluminum Nitride Materials with SIMS," annual meeting, American Ceramic Society, Dallas (1990). DOW CHEMICAL

W. E. Moddeman, R. T. Cassidy, L. F. Allard, "TEM and Auger Examinations of Oxidized Al-Containing Austenitic Stainless Steels for Glass/Metal Seal Applications," 14th Annual Conference on Composites and Advanced Ceramics, Cocoa Beach, FL, January 14-17, 1990. EG&G MOUND LABORATORIES

L. F. Allard, D. W. Coffey, W. E. Moddeman, and D. P. Kramer, "Nickel in LAS Glass to Metal Interfaces, Characterized by TEM and XPS," annual meeting, American Ceramic Society, Dallas (1990). EG&G MOUND LABORATORIES

L. F. Allard, D. W. Coffey, W. E. Moddeman, and D. P. Kramer, "Nickel in Las Glass to Metal Interfaces, Characterized by TEM and XPS," 14th Annual Conference on Composites and Advanced Ceramics, Cocoa Beach, FL, January 14-17, 1990. EG&G MOUND LABORATORIES

Arvid Pasto, Ceramic Tensile Testing at GTE Laboratories, Inc.," presented at the Tensile Testing Meeting at Oak Ridge National Laboratory, March 5, 1990. GTE LABORATORIES

M. K. Ferber, T. A. Nolan, M. G. Jenkins, and R. Yeckley, "Fatigue and Creep Behavior of Silicon Nitride at Elevated Temperatures," annual meeting, American Ceramic Society, Dallas (1990). NORTON TRW

T. A. Nolan, L. F. Allard, D. W. Coffey, M. H. Rawlins, and R. W. Nixdorf, "Microstructural Characterization of VLS TiN Whiskers," annual meeting, American Ceramic Society, Dallas (1990). REMAXCO

UNIVERSITY USERS PUBLICATIONS

Philip H. McCluskey, Robert K. Williams, Ron S. Graves, and Terry N. Tiegs, "Thermal Diffusivity/Conductivity of Alumina-Silicon Carbide Composites," *J. Am. Cer. Soc.*, Vol. 73, No. 2 (February 1990). ALFRED UNIVERSITY

James S. Wolf and O. Burl Cavin, "Oxidation and Sulfidation of Type 310S Stainless Steel at Elevated Temperatures," *Proceedings of the 29th Annual Conference of Metallography* "International Symposium on High Temperature Oxidation and Sulfidation Processes," Hamilton, Ontario, Canada, Aug. 26-30, 1990. CLEMSON UNIVERSITY

I. Baker, R. A. Padgett, and E. M. Schulson, "Auger Electron Spectroscopy Study of Ni_3Si," *Scripta Met.*, Vol. 23, 1969-1974 (1989). DARTMOUTH COLLEGE

W. J. Lackey, J. A. Hanigofsky, M. J. Shapiro, W. B. Carter, D. N. Hill, E. K. Barefield, E. A. Judson, D. F. O'Brien, Y. S. Chung, T. S. Moss, and K. L. More, "Preparation of Superconducting Wire by Deposition of $YBa_2Cu_3O_x$ Onto Fibers," *Proceedings of the 11th International Conference on Chemical Vapor Deposition*, Seattle, WA, October 14-19, 1990, Electrochemical Society. GEORGIA TECH

M. J. Shapiro, K. L. More, W. J. Lackey, J. A. Hanigofsky, D. N. Hill, W. B. Carter, E. K. Barefield, E. A. Judson, D. F. O'Brien, R. Patrick, and Y. S. Chung, "Interaction of Chemically Vapor Deposited $YBa_2Cu_3O_x$ with Yttria Stabilized Zirconia Substrates," accepted for publication in *J. Amer. Cera. Soc.* GEORGIA TECH

J. A. Hanigofsky, K. L. More. W. J. Lackey, and W. Y. Lee, "Characterization of the BN + AlN Single Phase and Codeposition System," accepted for publication in the *J. Amer. Cera. Soc.* GEORGIA TECH

G. B. Freeman, W. Y. Lee, W. J. Lackey, J. A. Hanigofsky, and K. L. More, "Grain Structure and Growth of Dispersed Phase NB-AlN Coatings Grown Via Chemical Vapor Deposition," *Proceedings of the 1990 MRS Fall Meeting*, Boston, November 26-December 1, 1990. GEORGIA TECH

J. A. Hanigofsky, K. L. More. W. J. Lackey, and W. Y. Lee, "Characterization of the BN + AlN Single Phase and Codeposition System," *Am. Cer. Soc. Bull.*, in press. GEORGIA TECH

M. H. Siedati, K. K. Chawla, and M. Ferber, "The Role of SnO_2 Interphase in an Alumina/Glass Composite: A Fractographic Study," submitted to the *J. Mat. Sci.* NEW MEXICO TECH

Y. C. Wang, H. S. Kong, J. T. Glass, R. F. Davis, and K. L. More, "Effect of Substrate Orientation on Interfacial and Bulk Character of Chemically Vapor Deposited Monocrystalline Silicon Carbide Thin Films," submitted to *J. Amer. Cera. Soc.* NORTH CAROLINA STATE UNIVERSITY

K. L. More, D. A. Koester, and R. F. Davis, "The Role of Interfaces in the Creep-Deformation of a SiC Whisker-Reinforced Si_3N_4 Composite," Electron Microscopy, 1990, 4, p. 382, L. D. Peachey and D. B. Williams, eds. (1990). NORTH CAROLINA STATE UNIVERSITY

K. L. More, D. A. Koester, and R. F. Davis, "Microstructural Characterization of a Creep-Deformed SiC Whisker-Reinforced Si_3N_4 Composite," submitted to *Ultramicroscopy*. NORTH CAROLINA STATE UNIVERSITY

H. L. M. Reis and K. L. Koenig, "On the Acoustic Emission Monitoring of the Martensitic Transformation in Magnesium Oxide Partially Stabilized Zirconia," submitted to the *British J. of Non-Destr. Insp.*, (1989). UNIVERSITY OF ILLINOIS

H. L. M. Reis and R. M. Sesek, "A Study of the Acousto-Ultrasonic Approach for Evaluation of Fatigue Damage in Ceramic Matrix Composite Materials," Technical Report, University of Illinois-Urbana (1989). UNIVERSITY OF ILLINOIS

H. L. M. Reis and R. M. Sesek, "Nondestructive Evaluation of High Temperature Damage in Magnesium Oxide Partially Stabilized Zirconia," Technical Report, University of Illinois-Urbana, (1989). UNIVERSITY OF ILLINOIS

H. L. M. Reis and R. M. Sesek, "Nondestructive Evaluation/Characterization of Advanced Ceramic Matrix Composites," Technical Report, University of Illinois-Urbana (1989). UNIVERSITY OF ILLINOIS

H. L. M. Reis and R. M. Sesek, "Nondestructive Evaluation/Characterization of Zirconia," Technical Report, University of Illinois-Urbana (1989). UNIVERSITY OF ILLINOIS

A. J. Burreson, "Characterization and Mechanical Property Evaluation of Nicalon SiC Fiber Reinforced Calcium Aluminate DSP Cement Matrix Composites," Thesis, University of Illinois-Urbana (1990). UNIVERSITY OF ILLINOIS

J. W. Jones, "A Mechanical Properties Microprobe Study of the Near-Surface Mechanical Behavior of Ion Beam Modified Ni Subjected to Low Cycle Fatigue," Thesis, University of Michigan (1989). UNIVERSITY OF MICHIGAN

Abhaya K. Datye, Xiaomei Qui, Theodore T. Borek, Robert T. Paine, University of New Mexico, Albuquerque, NM; and Lawrence F. Allard, "Stability of Boron Nitride Coatings on Ceramic Substrates", *Mat. Res. Soc.* "Better Ceramics Through Chemistry" Paper A11.10, in press. UNIVERSITY OF NEW MEXICO

L. F. Allard, A. K. Datye, T. A. Nolan, S. L. Mahan, and R. T. Paine, "High Resolution Electron Microscopy of BN on MgO, a Model Ceramic-Ceramic Interface," *Ultramicroscopy*, in press (1991 publication date). UNIVERSITY OF NEW MEXICO

Narendra B. Dahotre, Mary Helen McCay, T. Dwayne McCay, Santosh Gopinathan, and Lawrence F. Allard, "Pulse Laser Processing of a SiC/Al-Alloy Metal Matrix Composite," submitted to Materials *J. Mat. Res.*, in press (March 1991). UNIVERSITY OF TENNESSEE SPACE INSTITUTE

N. B. Dahotre, M. H. McCay, T. D. McCay, S., and Lawrence F. Allard, "Laser Welding of a SiC/Al-Alloy Metal Matrix Composite," submitted to *J. Mat. Res.* (UNIVERSITY OF TENNESSEE SPACE INSTITUTE

A. Choudhury, C. R. Brooks, and R. A. Padgett, "Auger Analysis of the Fracture Surfaces of a 12% Cr Steel Embrittled After 30 Years Service in a Fossil-Fired Power Plant," *Scripta Met.* (24), No. 8, p. 1593, August 1990. UNIVERSITY OF TENNESSEE

A. Choudhury, C. L. White, C. R. Brooks, "The Effect of Cathodic Hydrogen Charging of Substoichiomeric Ni3Al on AES Measured Intergranual Boron Segregation," to be published in *J. Vac. Sci. and Technol., A.* UNIVERSITY OF TENNESSEE

M. J. Godbole, A. J. Pedraza, and D. H. Lowndes, "Laser-Induced Interface Reactions of Copper Thin Films on Sapphire Substrates," *J. Mat. Res.*, Vol. 4, No. 5, p. 1202, October 31, 1989. UNIVERSITY OF TENNESSEE

M. J. Annen, D. Young, M. E. Davis, O. B. Cavin, and C. R. Hubbard, "Thermal and Hydrothermal Stability of VPI-5 by in situ X-ray Powder Diffraction," accepted by the *J. Phys. Chem.* VPI&SU

UNIVERSITY USERS PRESENTATIONS

M. A. Rodriguez, J. J. Simmins, P. H. McCluskey, R. Zhou, and R. L. Snyder, "$Y_1Ba_3Cu_2O_{6.5+\delta}$ - An Interesting Non-superconductor," Institute for Ceramic Superconductivity, New York State, College of Ceramics at Alfred University, Alfred, NY, September 29, 1988. ALFRED UNIVERSITY

James S. Wolf and O. Burl Cavin, "Oxidation and Sulfidation of Type 310S Stainless Steel at Elevated Temperatures," 29th Annual Conference of Metallography "International Symposium on High Temperature Oxidation and Sulfidation Processes," Hamilton, Ontario, Canada, August 26-30, 1990. CLEMSON UNIVERSITY

M. J. Shapiro, W. J. Lackey, J. A. Hanigofsky, W. B. Carter, E. K. Barefield, G. Neumeier, D. F. O'Brien, Y. S. Chung, A. J. Green, T. S. Moss, and K. L. More, "Substrate Interaction with Chemically Vapor Deposited $YBa_2Cu_3O_x$," annual meeting, American Ceramic Society, Dallas (1990). GEORGIA TECH

W. J. Lackey, W. Y. Lee, P. K. Agrawal, J. Hanigofsky, and K. L. More, "Dispersed Phase N+AlN Composites Via Chemical Vapor Deposition," annual meeting, American Ceramic Society, Dallas (1990). GEORGIA TECH

D. A. Koester, K. L. More, and R. F. Davis "Steady-State Creep of Hot-Pressed SiC Whisker-Reinforced Silicon Nitride," U.S. Japan Seminar, Tokyo, Japan, August 20-22, 1990. NORTH CAROLINA STATE UNIVERSITY

K. L. More, D. A. Koester, and R. F. Davis, "The Role of Interfaces in the Creep-Deformation of a SiC Whisker-Reinforced Si_3N_4 Composite," International Congress for Electron Microscopy, Seattle, WA, August 12-18, 1990. NORTH CAROLINA STATE UNIVERSITY

K. L. More, D. A. Koester, and R. F. Davis, "Microstructural Characterization of a Creep-Deformed SiC Whisker-Reinforced Si_3N_4 Composite," Frontiers of Electron Microscopy in Materials Science, Oak Brook, IL, May 20-24, 1990. NORTH CAROLINA STATE UNIVERSITY

L. A. Harris, J. L. Ong, and L. C. Lucas, "ESCA Analyses of Passivated Titanium and Ca-P Surfaces," 16th Annual Meeting of Society for Biomaterials, Charleston, SC, May 20-23, 1990. UNIVERSITY OF ALABAMA-BIRMINGHAM

L. A. Harris, J. L. Ong, and L. C. Lucas, "Characterization of Ca-P Coatings and Source Material Using XPS," 7th Cimtec-World Ceramics Congress, Italy, June 24-30, 1990. UNIVERSITY OF ALABAMA-BIRMINGHAM

B. Ballard, P. Predecki, C. R. Hubbard, "Residual Strains in Al_2O_3/SiCw Composite from 25-1000C," 39th Annual Denver X-ray Conference, Steamboat Springs, CO, July 30-Aug. 3, 1990. UNIVERSITY OF DENVER

H. L. M. Reis, "Nondestructive Evaluation/Characterization of Composite Materials and Structures Using the Acousto-Ultrasonic Approach," ASNT Chicago Section, November 6, 1989. UNIVERSITY OF ILLINOIS

A. K. Datye, R. T. Paine, C. K. Narula, and L. F. Allard, "Novel Approach for High Resolution TEM Studies of Ceramic-Ceramic Interfaces," MRS Spring Meeting, San Diego, April 24-28, 1989. UNIVERSITY OF NEW MEXICO

A. K. Datye, L. F. Allard, T. T. Borek, and R. T. Paine, "Stability of Boron Nitride Coatings on Ceramic Substrates," MRS Spring Meeting, San Francisco, April 16-21, 1990. UNIVERSITY OF NEW MEXICO

L. F. Allard, T. A. Nolan, A. K. Datye, R. T. Paine, "HREM of Model Ceramic Interfaces," presented at the Frontiers of Electron Microscopy in Materials Science, Oak Brook, IL, May 20-24, 1990.

UNIVERSITY OF NEW MEXICO

A. Choudhury, C. R. Brooks, R. A. Padgett, "Auger Analysis of the Fracture Surfaces of a High, Chromium Steel Embrittled After 30 Years of Service," Center for Materials Processing Annual Review, Knoxville, TN, March 22-23, 1990. UNIVERSITY OF TENNESSEE

T. B. Jackson, A. V. Virkar, and K. L. More, "The Microstructure of Aluminum Nitride Sintered with Yttria," annual meeting, American Ceramic Society, Dallas (1990). UNIVERSITY OF UTAH

T. B. Jackson, R. A. Cutler, and A. V. Virkar, "Effect of Y_2O_3 Concentration and Sintering Time on the Thermal Conductivity of Aluminum Nitride," annual meeting, American Ceramic Society, Dallas (1990). UNIVERSITY OF UTAH

K. M. Prettyman, J. Joe, A. V. Virkar, C. R. Hubbard, O. B. Cavin, and M. K. Ferber, "Ferroelastic Domain Switching in Three Mole Percent Yttria Doped Zirconia (t' phase)," annual meeting, American Ceramic Society, Dallas (1990). UNIVERSITY OF UTAH

LOCAL USERS and HTML STAFF PUBLICATIONS

These publications are in the alphabetical order of the first listed HTML User Staff Member.

L. F. Allard, K. S. Ailey-Trent, and T. A. Nolan, "Microstructural Characteristics of Pyrite Flamboids in Coal," submitted to *Fuel* (1990).

H. C. Foley, J. S. Brinen, and L. F. Allard, "Bimetallic Catalysts Comprised of Dissimilar Metals for the Reduction of Carbon Monoxide with Hydrogen," *Applied Catalysis*, in press.

C. E. Bamberger, L. F. Allard, D. W. Coffey, and M. R. Bennett, "Whiskers of TiN by Topachemical Reaction," submitted to *J. Crystal Growth* (1990).

T. N. Tiegs, L. F. Allard, P. F. Becher, and M. K. Ferber, "Identification and Development of Optimum Silicon Carbide Whiskers for Silicon Nitride Matrix Ceramics," *Proceedings of the Twenty-Seventh Automotive Technology Development Contractors' Coordination Meeting, Dearborn, Michigan, October 1989*, p. 167 (1990).

R. B. Dinwiddie and D. G. Onn, "Modeling the Temperature Dependence of the Thermal Conductivity of Aluminum Nitride," *Proceedings of the 21st International Thermal Conductivity Conference*, Lexington, KY, October 15-18, 1989, in press. Plenum Press

T. N. Tiegs, P. F. Becher, M. K. Ferber, and P. A. Menchhofer, "High Temperature Strength of SiC Whisker-Reinforced Silicon Nitride Composites," *Proceedings of the 7th CIMTEC World Ceramics Congress,* Montecatini Terme, Italy, June 24-30, 1990.

M. K. Ferber and P. F. Becher, "Static Fatigue Behavior of Polycrystalline BeO," submitted to the *J. Am. Cer. Soc.*

Felicia M. Foust, "A Tour of the High Temperature Materials Laboratory," ORNL Review, Vol. 22, No. 4 (1989).

R. K. Williams, J. Brynestad, T. J. Henson, D. M. Kroeger, G. C. Marsh, R. A. Padgett, and J. O. Scarbrough, "Preparation and Grain Boundary Chemistry of Dense Polycrystalline $YBa_2Cu_4O_8$," submitted to the *J. Applied Physics.*

Terrence B. Lindemer, John F. Hunley, Jacques E. Gates, Alfred L Sutton, Jr., Jorulf Brynestad, and Camden R. Hubbard, "Experimental and Thermodynamic Study of Nonstoichiometry in $YBa_2Cu_3O_{7-x}$," *J. Am. Cer. Soc.*, Vol. 72, No. 10, p. 1775 (October 1989).

R. G. Munro and C. R. Hubbard, "Development of the Property Database for Gas-Fired Applications of Ceramics," *Center for Advanced Materials Newsletter*, Vol. 3, No. 1 (1989) and *Amer. Cera. Soc. Bull.*, 68(12) 2084 (1989).

T. B. Lindemer, C. R. Hubbard, and J. Brynestad, "CO_2 Solubility in $YBa_2Cu_3O_{7-x}$," *Physica C* 167, 312-316, (1990).

K. Doverspike, C. R. Hubbard, R. K. Williams, K. B. Alexander, J. Brynestad, and D. M. Kroeger, "Anisotropic Thermal Expansion of the 1:2:4 Yttrium Barium Copper Oxide Superconductor," submitted to *Physica C*.

P. J. Maziasz, C. G. McKamey, and C. R. Hubbard, "Designing Precipitation: Strengthened Iron-Aluminides for High-Temperature Applications," *Proceedings of the MRS Spring 1990 Meeting*, San Francisco, April 16-22, 1990 (in press).

M. G. Jenkins, A. S. Kobayashi, and R. C. Bradt, "Crack Length Measurements of Ceramics at Elevated Temperatures Using the Laser Interferometric Displacement Gage," submitted to *Fatigue Crack Length: Techniques and Applications*, ed. K. J. Marsh, R. A. Smith, and R. Ritchie, Publisher, Engr. Matls. Advisory Sves., Ltd., U.K.

M. G. Jenkins, M. K. Ferber, V. J. Tennery, and J. A. Salem, "Determination of the Stress Distributions in a Ceramic, Tensile Specimen Using Numerical Techniques," *Proceedings of the 1990 ASME International Computers in Engineering Conference and Exposition*, Boston, Aug 5-9, 1990 (in press).

M. G. Jenkins, M. K. Ferber, V. J. Tennery, and J. A. Salem, "Determination of the Stress Distributions in a Ceramic, Tensile Specimen Using Numerical Techniques," *Proceedings of the 1990 ASME International Computers in Engineering Conference and Exposition*, Boston, Vol 2, p. 217 (1990).

Michael G. Jenkins, Mattison K. Ferber, Ralph L. Martin, and Victor J. Tennery, "Numerical and Empirical Verification of the Stress State in a Ceramic, Button-head, Tensile Specimen," *Proceedings of the Twenty-Seventh Automotive Technology Development Contractors' Coordination Meeting, Dearborn, Michigan, October 1989*, p. 245 (1990).

D. P. Stinton, D. M. Hembree, Jr., K. L. More, B. W. Sheldon, T. M. Besmann, M. H. Headinger, and R. F. Davis, "Matrix Characterization of Fiber-Reinforced SiC Matrix Composites Fabricated by Chemical Vapor Infiltration," submitted to *J. Am. Ceram. Soc.*

K. L. More, H. S. Kong, J. T. Glass, and R. F. Davis, "Electron Microscopy of Defects in Epitaxical beta-SiC Thin Films Grown on Silicon and Carbon {0001} Faces of alpha-SiC Substrates," *J. Am. Ceram. Soc.*, 73(5) p. 1283 (1990).

Y. C. Wang, H. S. Kong, J. T. Glass, R. F. Davis, and K. L. More, "Effects of Substrate Orientation on Interfacial and Bulk Character of Chemically Vapor Deposited Monocrystalline Silicon Carbide Thin Films," *J. Amer. Soc.*, 73(5) p. 1289 (1990).

R. E. Clausing, L. Heatherly, E. D. Specht, K. L. More, and G. M. Begun, "Growth Mechanisms, Film Morphology, Texture and Stresses for Three Types of Hot Filament Assisted CVD Diamond Film Growth," to be published as an extended abstract in *Carbon*.

R. E. Clausing, L. Heatherly, E. D. Specht, and K. L. More, "Growth Mechanisms Film Morphology, Texture and Stresses for HFACVD Diamond Film Growth," to be published in *NATO Proceedings of the NATO Meeting on Diamond and Diamondlike Films and Coatings, Pascoli, Italy, July 22-August 3, 1990.*

R. E. Clausing, L. Heatherly, E. D. Specht, and K. L. More, "Texture Development in Diamond Films Grown by Hot Filament CVD Processes," to be published in the *Proceedings of the 2nd International Conference on New Diamond Science and Technology, Washington, D.C., September 24-27, 1990.*

R. A. Lowden and K. L. More, "The Effect of Fiber Coatings on Interfacial Shear Strength and the Mechanical Behavior of Ceramic Composites," in Interfaces in Composites, *Materials Research Society Symposium Proceedings*, 170, C. G. Pantano and E. J. H. Chen, eds., Materials Research Society, Pittsburgh, p. 205 (1990).

D. P. Stinton, D. M. Hembree, Jr., K. L. More, B. W. Sheldon, and T. M. Besmann, "Characterization of Ceramic Matrix Composites Fabricated by Chemical Vapor Deposition," in Chemical Vapor Deposition of Refractory Metals and Ceramics, *Materials Research Society Symposium Proceedings*, 168, T. M. Besmann and B. M. Gallois, eds., Materials Research Society, Pittsburgh, p. 273 (1990).

R. D. James, R. A. Lowden, and K. L. More, "The Effects of Oxidation and Combustion Environment on the Properties of Nicalon/SiC Composites," to be published in the *Proceedings, 2nd International Ceramic Science and Technology Congress, Orlando, FL, Nov, 12-15, 1990.*

R. A. Lowden, K. L. More, T. M. Besmann, and R. D. James, "Microstructural Characterization of Multiphase Coatings Produced by Chemical Vapor Deposition," in Chemical Vapor Deposition of Refractory Metals and Ceramics, *Materials Research Society Symposium Proceedings*, 168, T. M. Besmann and B. M. Gallois, eds., Materials Research Society, Pittsburgh, p. 159 (1990).

S. P. Withrow, K. L. More, R. A. Zuhr, and T. E. Haynes, "Ion Beam Deposition of Beta-SiC Layers onto Alpha-SiC Substrates," *Vacuum*, 39(11-12), (1989) p. 1065.

K. L. More, S. P. Withrow, and T. E. Haynes, "Growth of Epitaxical SiC Layers onto On- and Off-Axis 6H-SiC Substrates by Ion Beam Deposition," Diamond, Boron Nitride, Silicon Carbide, and Related Wide Bandage Semiconductors, Materials Research Society Symposium Proceedings, 162, J. T. Glass, R. Messier, and N. Fujimori, Eds., MRS, Pittsburgh p. 208 (1990).

T. A. Nolan, L. F. Allard, A. Choudhury, D. W. Coffey, T. A. Dodson, L. A. Harris, T. J. Henson, K. L. More, R. A. Padgett, and V. J. Tennery, "Materials Analysis User Center," *Ceramic Technology Newsletter*, No. 26, p. 5, Jan-Mar 1990.

J. H. Schneibel, J. A. Horton, and W. D. Porter, "Bend Ductility and Physical Properties of Extruded Chromium-Modified Al_3Ti," submitted to *J. Mater. Res.*

C. J. Sparks, W. D. Porter, J. H. Schneibel, W. C. Oliver, and C. G. Golec, "Formation of Cubic $L1_2$Phases from Al_3Ti and Al_3Zr by Transition Metal Substitution for Al," to be published in *Materials Research Society Symposium Proceedings*, Vol. 186, G. M. Stocks, D. P. Pope, and A. F. Giamei, eds., Materials Research Society, Pittsburgh.

V. J. Tennery and M. K. Ferber, "Fracture Strength Analysis of Silicon Nitride and Silicon Carbide Ceramics from an International Cooperative Research Program, *Proceedings of the Twenty-Seventh Automotive Technology Development Contractors' Coordination Meeting, Dearborn, Michigan*, October 1989, p. 265 (1990).

V. J. Tennery and F. M. Foust, High Temperature Materials Laboratory Second Annual Report (October 1988 through September 1989), ORNL/TM-11418, December 1989.

E. L. Fuller, Jr., and V. J. Tennery, "Analytical Characterization of Coal Surfaces and Interfaces," *Proceedings of the AR&TD Direct Utilization and Instrumentation and Diagnostics Contractors Review Meeting, Pittsburgh,* September 16-18, 1990.

LOCAL USERS and HTML STAFF PRESENTATIONS

L. F. Allard, "Energy Dispersive Microanalysis in the Transmission Electron Microscope," invited talk, AVS/ASM Meeting on Modern Analytical Techniques in Materials Science, Oak Ridge, TN, June 1990.

L. F. Allard, T. A. Nolan, and T. N. Tiegs, "The Ultrastructure of SiC Whiskers: Crystallography and Chemistry of Surfaces and Inclusions," invited talk, TMS Meeting, Indianapolis, IN, October 1989.

L. F. Allard, and T. A. Dodson, "Pre-Alignment Steps for Coma-Free Operation of the JEOL 4000EX TEM," JEOL 4000EX User Group Meeting, Seattle, WA, August 13, 1990.

T. A. Dodson, and L. F. Allard, "Interfacing a JEOL 4000EX to an Apple Macintosh," JEOL 4000EX User Group Meeting, Seattle, WA, August 13, 1990 (39).

L. F. Allard, "The HTML at ORNL - A National Resource," East Tennessee Chapter of SAMPE, Knoxville, TN, September 18, 1990.

L. F. Allard, and T. A. Nolan, "Future Directions in Electron Microscopy," Jeol, Ltd., Akashima, Japan, March 26, 1990.

L. F. Allard, and T. A. Nolan, "Future Directions in Electron Microscopy," Hitachi Naka Works, Katsuta, Japan, March 29-30, 1990.

L. F. Allard, "The Ultra Structure of Silicon Carbide Whiskers and Whisker-Reinforced Composites," ORAU Traveling Lecture Program, UNC Charlotte, NC, February 22, 1990.

L. F. Allard, "Microcharacterization of Advanced Ceramics at the HTML, ORNL," New England Society for Electron Microscopy, Boston, MA, December 1, 1989.

L. F. Allard, T. A. Nolan, and D. W. Coffey, "The Microstructure of a Tin Whisker-Reinforced Nickel Aluminide Metal-Matrix Composite," annual meeting, American Ceramic Society, Dallas, TX, (1990).

O. B. Cavin, and C. R. Hubbard, "Problems Encountered During Non-Ambient X-Ray Diffraction," 39th Annual Denver X-Ray Conference, Steamboat Springs, CO, July 30-August 3, 1990.

R. B. Dinwiddie, and D. G. Onn, "Modelling Temperature Dependence of the Thermal Conductivity of Aluminum Nitride," 21st International Thermal Conductivity Conference, Lexington, KY, October 15-18, 1989.

R. B. Dinwiddie, "Thermal Conductivity of Beryllium," USASDC Material Properties Working Group, Teledyne Brown Engineering, Huntsville, AL, September 27, 1990.

R. Dinwiddie, and D. G. Onn, "Temperature Dependence of the Thermal Conductivity of Materials for Microelectronic Packaging: Measuring and Modelling Effects of Microstructure and Impurities," MRS Fall Meeting 1989, Boston, MA, November 27-December 2, 1989.

T. A. Dodson, and D. C. Joy, "Fast Fourier Transform Techniques for Measuring SEM Resolution," INTL Congress for Electron Microscopy, Seattle, WA, August 12-18, 1990.

M. K. Ferber, M. G. Jenkins, and V. J. Tennery, "Comparison of Tension, Compression, and Flexure Creep for Alumina and Silicon Nitride Ceramics," 14th Annual Conference on Composites and Advanced Materials, Cocoa Beach, FL, January 14-17, 1990.

M. K. Ferber, M. G. Jenkins, and V. J. Tennery, "Comparison of Tension, Compression, and Flexure Creep for Alumina and Silicon Nitride Ceramics," 14th Annual Conference on Composites and Advanced Materials, Cocoa Beach, FL, January 14-17, 1990.

M. K. Ferber, M. G. Jenkins, T. A. Nolan, and D. W. Coffey, "Fatigue and Creep Behavior of Silicon Nitride at Elevated Temperatures," presented to R. Yeckley, Norton/TRW.

R. A. Lowden, W. C. Oliver, and M. K. Ferber, "Interface Effects and Fracture in Fiber-Reinforced Ceramic," 14th Annual Conference on Composites and Advanced Ceramics, Cocoa Beach, FL, January 14-17, 1990.

C. R. Hubbard, O. B. Cavin, C. G. McKamey, and P. J. Maziasz, "Phase Equilibria of Fe-28Al Alloys by High Temperature XRD," 39th Denver X-Ray Conference, Steamboat Springs, CO, July 30-August 3, 1990.

C. R. Hubbard, R. B. Dinwiddie, O. B. Cavin, W. D. Porter, and M. K. Ferber, "The Effect of Intergranular Phases on the Thermophysical Properties of Silicon Nitride," annual meeting, American Ceramic Society, Dallas, TX, (1990).

C. R. Hubbard, and O. B. Cavin, "Research Opportunities at the High Temperature Materials Laboratory X-Ray Diffraction and Physical Properties User Centers," 39th Annual Denver X-Ray Conference, Steamboat Springs, CO, July 30-August 3, 1990.

K. Doverspike, C. R. Hubbard, and R. K. Williams, "$Y_1Ba_2Cu_4O_8$ Superconductor-Phase Pure Preparation, Ca Doping and Characterization," annual meeting, American Ceramic Society, Dallas, TX, (1990).

C. R. Hubbard, O. B. Cavin, and T. B. Lindemer, "High Temperature XRD Studies of the Y1Ba2Cu408 Superconductor," 39th Annual Denver X-Ray Conference, Steamboat Springs, CO, July 30-August 3, 1990.

C. R. Hubbard, O. B. Cavin, and C. G. McKamey, "Phase Equilibria of Fe-28Al Alloys by High Temperature XRD," 39th Annual Denver X-Ray Conference, Steamboat Springs, CO, July 30-August 3, 1990.

M. G. Jenkins, M. K. Ferber, V. J. Tennery, and J. A. Salem, "Determination of the Stress Distributions in a Ceramic, Tensile Specimen Using Numerical Techniques," 1990 ASME International Computers in Engineering Conference and Exposition, Boston, MA, August 5-9, 1990.

M. G. Jenkins, M. K. Ferber, R. L. Martin, R. M. Poteat, and V. J. Tennery, "Numerical and Empirical Verification of the Stress State in a Ceramic, Buttonhead, Tensile Specimen," Annual Automotive Technology Development Contractors Coordination Meeting, Dearborn, MI, Oct. 23-26, 1989.

M. G. Jenkins, M. K. Ferber, and R. L. Martin, "Numerical and Empirical Verification of the Stress State in a Ceramic, Button-Head, Tensile Specimen," 27th Annual Automotive Technology Development Contractors Coordination Meeting, Dearborn, MI, October 23-26, 1989.

M. G. Jenkins, A. Ghosh, and A. Akura, "Micro-Mechanical Modeling of Crack Growth Resistance in a Carbon/Carbon Composite," International Conference on Micromechanics, Albuquerque, NM, June 6-8, 1990.

M. G. Jenkins, M. K. Ferber, and A. Ghosh, "Non-Linear Fracture Resistance Characterization of Structural Ceramics at Elevated Temperatures," annual meeting, American Ceramic Society, Dallas (1990).

M. G. Jenkins, M. K. Ferber, and R. L. Martin, "Numerical and Empirical Verification of the Stress State in a Ceramic, Button-Head, Tensile Specimen," 27th Annual Automotive Technology Development Contractors Coordination Meeting, Dearborn, MI, October 23-26, 1989.

M. G. Jenkins, M. K. Ferber, and R. L. Martin, "Evaluation of the Stress State in a Button-head, Tensile Specimen for Monolithic and Composite Ceramics," 14th Annual Conference on Composites and Advanced Ceramics, Cocoa Beach, FL, January 14-17, 1990.

R. E. Clausing, L. Heatherly, E. D. Specht, K. L. More, and G. M. Begun, "Growth Mechanisms, Film Morphology, Texture and Stresses for Three Types of Hot Filament Assisted CVD Diamond Film Growth," Workshop on the Science and Technology of Diamond Thin Films, Quail Hollow, OH, May 20-23, 1990.

R. E. Clausing, L. Heatherly, E. D. Specht, and K. L. More, "Growth Mechanisms Film Morphology, Texture and Stresses for HFACVD Diamond Film Growth," NATO Meeting on Diamond and Diamondlike Films and Coatings, Pascoli, Italy, July 22-August 3, 1990.

R. E. Clausing, L. Heatherly, E. D. Specht, and K. L. More, "Texture Development in Diamond Films Grown by Hot Filament CVD Processes," 2nd International Conference on New Diamond Science and Technology, Washington, D.C., September 24-27, 1990.

R. A. Lowden, K. L. More, and R. D. James, "The Effects of Oxidation on the Properties of the Fiber-Matrix Interface in Nicalon/SiC Composites," Fossil Energy AR&TD Materials Program Conference Oak Ridge, TN, May 15-17, 1990.

D. P. Stinton, R. H. Krabill, K. L. More, D. M. Henmbree, and R. A. Lowden, "Characterization of Fiber-Reinforced SiC-Matrix Composites Fabricated by Chemical Vapor Infiltration," Fossil Energy AR&TD Materials Program Conference, Oak Ridge, TN, May 15-17, 1990.

R. A. Lowden, T. M. Besmann, and K. L. More, "The Effect of Molybdenum and Chromium Additions on the Oxidation Properties of CVD Silicon Carbide and Silicon Nitride," 14th Ann. Conf. Composites and Advanced Ceramics, Cocoa Beach, FL, January 14-17, 1990.

K. L. More, S. P. Withrow, and T. E. Haynes, "Growth of Epitaxical SiC Layers Onto On- and Off-Axis 6H-Sic Substrates by Ion Beam Deposition," MRS Fall Meeting, Boston, MA, November 27-December 2, 1989, MRS

K. L. More, S. P. Withrow, and T. E. Haynes, "Growth of Epitaxical SiC Layers onto On- and Off-Axis 6H-SiC Substrates by Ion Beam Deposition," MRS Fall Meeting 1989, Boston, MA, November 27-December 2, 1989.

W. D. Porter, C. R. Hubbard, R. B. Dinwiddie, and O. B. Cavin, "Research Opportunities at the High Temperature Materials Laboratory Physical Properties and X-Ray Diffraction User Centers," 19th NATAS Conference, Cambridge, MA, September 23-26, 1990.

C. J. Sparks, W. D. Porter, J. H. Schneibel, W. C. Oliver, and C. G. Golec, "Formation of Cubic $L1_2$Phases from Al_3Ti and Al_3Zr by Transition Metal Substitution for Al," MRS Spring Meeting, San Francisco, CA, April 16-20, 1990.

V. J. Tennery, "The High Temperature Materials Laboratory: A New Experience at a National Facility," R&D Facilities Conference, New Concepts for Flexible, Cost-Effective Buildings, Philadelphia, PA, May 9-10, 1990.

V. J. Tennery and M. K. Ferber, "Cooperative International Program on Mechanical Strength Measurements of Ceramics," Annual Automotive Technology Development Contractors Coordination Meeting, Dearborn, MI, October 22-25, 1990.

V. J. Tennery and M. K. Ferber, "Fracture Strength Analysis of Silicon Nitride and Silicon Carbide Ceramics from an International Cooperative Research Program," Japan Fine Ceramics Association Headquarters, Tokyo, Japan, May 23, 1990.

V. J. Tennery, E. L. Fuller, Jr., T. A. Nolan, L. F. Allard, K. S. Ailey-Trent, D. W. Coffey, and L. A. Harris, "Analytical Characterization of Coal Surfaces and Interfaces," AR&TD Direct Utilization and Instrumentation and Diagnostics Contractors Review Meeting, Pittsburgh, PA, September 16-18, 1990.

PENDING PRESENTATIONS

37th Sagamore Conference on Structural Ceramics, Plymouth, MA, October 1-4, 1990.

M. K. Ferber, M. G. Jenkins, and V. J. Tennery, "Comparison of Tension, Compression, and Flexure Creep for Alumina and Silicon Nitride Ceramics."

11th International Conference on Chemical Vapor Deposition, Seattle, WA, October 14-19, 1990

W. J. Lackey, J. A. Hanigofsky, M. J. Shapiro, W. B. Carter, D. N. Hill, E. K. Barefield, E. A. Judson, D. F. O'Brien, Y. S. Chung, T. S. Moss, and K. L. More, "Preparation of Superconducting Wire by Deposition of $YBa_2Cu_3O_x$ Onto Fibers." GEORGIA TECH

Pacific Coast meeting of the American Ceramic Society, Seattle, WA, October 25-27, 1990.

M. G. Jenkins, M. K. Ferber, and J. A. Salem, "Increased Fracture Resistance Due to Beneficial Residual Stresses in a Particulate Ceramic Composite."

2nd International Ceramic Science and Technology Congress, Orlando, FL, November 12-15, 1990.

R. D. James, R. A. Lowden, and K. L. More, "The Effects of Oxidation and Combustion Environment on the Properties of Nicalon/SiC Composites."

K. L. More, D. A. Koester, and R. F. Davis, "Creep Behavior of a SiC Whisker-Reinforced Si_3N_4 Composite in Air and Nitrogen."

Normand D. Corbin and Kerry N. Siebein, and R. A. Padgett, "Interfaces in SiC Whisker Reinforced Si_3N_4 Composites." NORTON COMPANY

MRS 1990 Fall Meeting, Boston, November 26-December 1, 1990

W. J. Lackey, J. A. Hanigofsky, M. J. Shapiro, W. B. Carter, D. N. Hill, E. K. Barefield, E. A. Judson, D. F. O'Brien, Y. S. Chung, T. S. Moss, and K. L. More, "Preparation of Superconducting Wire by Deposition of YBa2Cu3Ox Onto Fibers." GEORGIA TECH

G. B. Freeman, W. Y. Lee, W. J. Lackey, J. A. Hanigofsky, and K. L. More, "Grain Structure and Growth of Dispersed Phase NB-AlN Coatings Grown Via Chemical Vapor Deposition." GEORGIA TECH

L. F. Allard, A. K. Datye, and R. T. Paine, "Atomic Structure of Crystalline Boron Nitride Interface with Ceramic Substrates." UNIVERSITY OF NEW MEXICO

C. R. Hubbard, R. B. Dinwiddie, W. D. Porter, and M. K. Ferber, "The Effect of Intergranular Phases and Thermal Treatment on the Thermophysical Properties of Silicon Nitride."

15th Annual Conference on Composites and Advanced Ceramics, Cocoa Beach, January 13-16, 1991.

W. S. Hong, J. M. Sater, and M. A. Rigdon, "The Effect of Varying Test Parameters on the Measured High Temperature Strength of SCS-6 Fiber." INSTITUTE FOR DEFENSE ANALYSIS

K. L. More, D. A. Koester, and R. F. Davis, "Creep of a SiC Whisker-Reinforced Si_3N_4 Composite in Compression and Bending." NORTH CAROLINA STATE UNIVERSITY

R. E. Clausing, L. Heatherly, E. D.Specht, K. L. More, and L. L. Horton, "Growth Mechanisms, Film Morphology, and Defect Characterization for CVD Diamond Films."

B. Ballard, P. Predecki, C. R. Hubbard, "Residual Strains in Al_2O_3/SiCw Composite from 25-1000C,"

M. K. Ferber and T. N. Tiegs, "Effects of Post-Sintering Microwave Treatments Upon the Mechanical Performance of Silicon Nitride."

T. A. Nolan, M. K. Ferber, and D. W. Coffey, "Microstructural Characterization of Tensile and Flexural Creep Deformation and Fatigue in a Si_3N_4 Ceramic."

PATENT APPLICATIONS

A disclosure entitled "Microwave-Compatible Dilatometer," by H. K. Kimrey, Jr., M. A. Janney, and M. K. Ferber, ESID 652-X, was submitted on April 10, 1990.

ORNL/TM—11735

INTERNAL DISTRIBUTION

1-2. Central Research Library
3. Document Reference Section
4-5. Laboratory Records Department
6. Laboratory Records, ORNL RC
7. ORNL Patent Section
8-10. M&C Records Office
11. D. J. Alexander
12. K. B. Alexander
13. L. F. Allard
14. P. Angelini
15. B. R. Appleton
16. R. L. Beatty
17. J. Bentley
18. T. M. Besmann
19. A. Bleier
20. K. W. Boling
21. R. A. Bradley
22. C. R. Brinkman
23. V. R. Bullington
24. R. S. Carlsmith
25. O. B. Cavin
26. D. R. Childress
27. A. Choudhury
28. D. W. Coffey
29. D. D. Conger
30. G. L. Copeland
31. D. F. Craig
32. S. L. Davis
33. R. B. Dinwiddie
34. L. Dunlap
35. N. D. Evans
36. M. K. Ferber
37-41. F. M. Foust
42. R. L. Freeny
43. W. Fulkerson
44. F. M. Haggag
45. D. K. Hensley
46. R. Holbrook
47. L. L. Horton
48. C. Hsueh
49. C. R. Hubbard
50. T. J. Huxford
51. M. G. Jenkins
52. V. T. Jenkins
53. D. R. Johnson
54. R. R. Judkins
55. M. A. Karnitz
56. E. A. Kenik
57. O. F. Kimball
58. T. G. Kollie
59. M. B. Lewis
60. E. L. Long Jr.
61. L. K. Mansur
62. M. M. Martin
63. R. C. Martin
64. R. L. Martin
65. M. C. Matthews
66. J. R. Mayotte
67. A. J. Moorhead
68. K. L. More
69. J. W. Nave
70. T. A. Nolan
71. D. F. Pedraza
72. W. D. Porter
73. C. R. Richmond
74. G. R. Romanoski
75. A. R. Sadlowe
76. A. C. Schaffhauser
77. M. A. Schmidt
78. B. W. Sheldon
79. L. G. Shrader
80. G. M. Slaughter
81. R. R. Steele
82. R. L. Swain
83-87. V. J. Tennery
88-91. P. T. Thornton
92. D. B. Trauger
93. L. J. Turner
94. R. Ward
95. J. R. Weir
96. F. W. Wiffen
97. D. F. Wilson
98. N. F. Wright
99. A. D. Brailsford (Consultant)
100. M. L. Savitz (Consultant)
101. J. B. Wachtman (Consultant)

EXTERNAL DISTRIBUTION

102. AIR PRODUCTS, R&D Lab No. 1, 7201 Hamilton Boulevard, Allentown, PA 18195

F. Kimock

103-105. ALFRED UNIVERSITY, New York State College of Ceramics, P.O. Box 771, Alfred, NY 14802

D. P. Matheis
J. J. Simmons
R. L. Snyder

106. ALLIED-SIGNAL AEROSPACE COMPANY, 717 N. Bendix Drive, South Bend, IN 46620

R. Rateich

107-109. ALLIED-SIGNAL AEROSPACE COMPANY, Garrett Ceramic Components Division, 19800 South Van Ness Avenue, Torrance, CA 90509

B. J. Busovne, Jr.
M. V. Mitchell
H. C. Yeh

110-111. ALLIED-SIGNAL AEROSPACE COMPANY, Garrett Engine Division, MS 301-2N, 111 S. 34th St., P.O. Box 5217, Phoenix, AZ 85010

H. Fang
B. O'Halloran

112-113. ALLIED-SIGNAL CORPORATE TECHNOLOGY, Box 1021 R, Morristown, NJ 07960

C. Ballard
P. Whalen

114. ALLIED-SIGNAL ENGINEERED MATERIALS RESEARCH CENTER, 50 East Algonquin Road, Box 5016, Des Plaines, IL 60017

K. R. Karasek

115. ALUMINUM COMPANY OF AMERICA, Alcoa Technical Center, Product Design and Mechanics Division, Alcoa Center, PA 15069

H. F. Wu

116. AMERICAN SUPERCONDUCTOR, 149 Grove Street, Watertown, MA 02172

P. Gallien

117. APPLIED SCIENCES, INC., 800 Livermore Street, Yellow Springs, OH 45387

J.-M. Ting

118. CARBOMEDICS, INC., 1300 B East Anderson Lane, Austin, TX 78753

D. W. James

119-120. THE CARBORUNDUM CO., P.O. Box 832, Bldg. 100, Niagara Falls, NY 14302

R. Storm
K. R. Sellkregg

121-122. CATERPILLAR, INC., Technical Center, Bldg. E, P.O. Box 1875, Peoria, IL 61656-1875

H. D. Lawrence
L. Voellinger

123-127. CERAMICS PROCESS SYSTEMS, 155 Fortune Blvd., Milford, MA 01757

L. J. Klemptner
R-R. Lee
B. Novich
D. L. Quellette
M. Parrish

128. CHRYSLER CORPORATION, CIMS 418-17-09, 12000 Chrysler Drive, High Land Park, MI 48288-1118

D. Wetzel

129-134. CLEMSON UNIVERSITY, College of Engineering, Department of Mechanical Engineering, 318 Riggs Hall, Clemson, SC 19634-0921

P. K. Chaudhury
M. Grujicic
M. C. Long
K. Preston
H. J. Rack
J. S. Wolf

135-137. COORS CERAMICS CO., 17750 W 32nd Avenue, Golden, CO 80401

J. Coors
M. Readey
J. Sibold

138. COORS TECHNICAL CERAMIC CO., 1100 Commerce Park Drive, Oak Ridge, TN 37830

W. Howe

139-140. CORNING GLASS WORKS, Technical Ceramics, MP WX 01 05, Corning, NY 14831

M. J. Henderson
W. R. Prindle

141. CONSULTING SERVICES, 12 Holland Road, Pittsburgh, PA 15235

C. Schacht

142-143. CUMMINS ENGINE CO., INC., Box 3005, MC 50183, Columbus, IN 47202

J. W. Patten
J. Bokelman

144. CVC Products, 6305 York Road, Suite 40, Baltimore, MD 21212

F. Grunewald

145. DARTMOUTH COLLEGE, Thayer School of Engineering, Hanover, NH 03755

I. Baker

146-149. DETROIT DIESEL CORPORATION, World Headquarters, 13400 Outer Drive West, Detroit, MI 48239-4001

D. Giles
C. L. Hoberty
W. Lakso
K. Weber

150. DETROIT GASKET, Route 7, Box 7, Newport, TN 37821

M. L. Surbrook

151. DG TRIM PRODUCTS, 3204 Regal Drive, Alcoa, TN 37701

M. W. Hobbs

152-157. THE DOW CHEMICAL CO., Analytical Science Laboratory, Midland, MI 48674

A. M. Hart
A. Knudson
G. Potter
W. Rafaniello
P. D. Stone
J. Tou

158-160. DOW CORNING CORPORATION, 3901 S. Saginaw Road, MS 43, Midland, MI 48640

H. W. Fogelsong
W. E. Hauth
S. S. Snow

161-162. EG&G MOUND APPLIED TECHNOLOGIES, INC., P.O. Box 3000, Miamisburg, OH 45343

P. Gray
W. E. Moddeman

163. EKZO CHEMICAL, INC., Livingston Avenue, Dobbs Ferry, NY 10522

K. Kiss

164-165. ENERGY CONVERSION DEVICES, INC., 1675 West Maple Road, Troy, MI 48084

B. Chao
R. T. Young

166-167. ENGELHARD CORPORATION, Menlo Park, P. O. Box 2900, Edison, NJ 08818-2900

M. Hamil
J. St. Amand

168. ETHEL CORPORATION, Ethyl Technical Center, P. O. Box 14799, Baton Rouge, LA 70898

M. Gluckstein

169-170. FIBER MATERIALS, INC., Biddeford Industrial Park, Biddeford, ME 04005

D. Dunn
M. K. Marshall

171. FMC CORPORATION, Advanced Systems Center, 1300 South Second Street, P. O. Box 59043, Minneapolis, MI 55459-0043

J. Koo

172. FORD ELECTRONICS TECHNOLOGY CENTER, 17000 Rotunda Drive, Dearborn, MI 48121

K. Salisbury

173. FOSTER-MILLER, INC., 350 Second Avenue, Waltham, MA 02254

P. Stark

174. GBC CORPORATION, Monestary Drive, LaTrobe, PA 15650

E. R. Tostevin

175-176. GENERAL ELECTRIC AIRCRAFT ENGINES, 1 Neumann Way, Cincinnati, OH 45215

R. Harrison
L. Lisiecki

177-178. GENERAL MOTORS, Allison Gas Turbine Operations, P.O. Box 420, Indianapolis, IN 46206-54748

L. Groseclose
H. E. Helms

179-183. THE GEORGIA INSTITUTE OF TECHNOLOGY, 110 Baker Building, Atlanta, GA 30332

J. A. Hanigofsky
W. J. Lackey
H. R. Last
J. Lyons
T. H. Sanders

184-186. THE GEORGIA INSTITUTE OF TECHNOLOGY, Center for the Advancement of Computational Mechanics, Department of Civil Engineering, MC 0355, Atlanta, GA 30332

S. N. Atlur
J. S. Epstein
G. May

187. GREAT LAKES RESEARCH, P.O. Box 1831, Elizabethton, TN 37643

E. G. Morris

188-193. GTE LABS, INC., 40 Sylvan Road, Waltham, MA 02254

A. E. Pasto
J. Hefter
F. Strouse
C-M. Sung
W. C. VanSchalkwyk
G. Wei

194. GTE LABS, Valenite, Materials Manufacturing, 1100 West 13th Mile Road, Madison Heights, MI 48071

J. T. Smith

195. HiTc SUPERCONCO, INC., Lambertville, NJ 08530

R. B. Cass

196-198. INSTITUTE FOR DEFENSE ANALYSES, 1801 N. Beauregard Street, Alexandria, VA 22311

W. S. Hong
M. A. Rigdon
J. M. Sater

199. INSTRON, Corporate Technical Director, 100 Royall Street, Canton, MA 02021

J. Amaral

200. INSTRON CORPORATION, 3781 N.E. Expressway, Suite 132, Atlanta, GA 30340

M. Mayer

201-204. IONIC ATLANTA, INC., 1347 Spring Street, Atlanta, GA 30309

K. O. Legg
S. G. Pope
H. Solnick-Legg
J. R. Stevenson

205-206. THE JOHNS HOPKINS UNIVERSITY, Department of Materials Science and Engineering, 102 Maryland Hall, Baltimore, MD 21218

R. C. Cammarata
T. E. Schlesinger

207. KEMET ELECTRONICS, P.O. Box 5928, Greenville, SC 29606

L. Mann

208. LANXIDE CORPORATION, Tralee Industrial Park, P.O. Box 6077, Newark, DE 19714-6077

J. Wang

209. LAWRENCE LIVERMORE LABORATORY, P.O. Box 808, MS L 566, Livermore, CA 94550

A. Tesar

210-211. LITTON INDUSTRIES, P.O. Box 87, 5500 Canoga Avenue, Woodland Hills, CA 91367

R. A. Hansen
F. Lee

212. MARTIN MARIETTA AERO NAVAL SYSTEMS, 103 Cheasepeake Park Plaza, Baltimore, MD 21220

D. Trawinski

213. MARTIN MARIETTA LABORATORIES, 1450 South Rolling Road, Baltimore, MD 21227

A. Barrett

214-215. MCDONNELL DOUGLAS CORPORATION, P. O. Box 516, St. Louis, MO 63166

D. A. Bowers
J. W. Sapp, Jr.

216. MICHIGAN STATE UNIVERSITY, Engineering Research Facility, 2857 Jolly Road, Okemos, MI 48864

T. Rachel

217-218. MICHIGAN TECHNOLOGY UNIVERSITY, Houghton, MI 49931

D. Nelson
C. White

219-221. MINIATURE PRECISION BEARINGS, Division of MPB Corporation, Precision Park, P.O. Box 547, Keene, NH 03431-0547

K. M. Gordon
R. A. Hanson
R. L. Houghton

222-224. MOBIL RESEARCH AND DEVELOPMENT CORPORATION, Central Research Laboratory, Pennington Rocky Hill Road, Pennington, NJ 08534

C. R. Aguinaldo
D. Olson

225. MONARCH TILE MANUFACTURING, INC., P.O. Box 999, Florence, AL 35630

J. Ranney

226. MONTANA TECHNOLOGY COMPANY, INC., Applied Testing Laboratory, 321 West Galena Street, Butte, MT 59701

F. Bradley

227. MSE, INC., P.O. Box 3767, Butte, MT 59702

V. Griffiths

228. NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY, Department of Materials and Metallurgical Engineering, Socorro, NM 87801

K. K. Chawla

229-231. NORTH CAROLINA STATE UNIVERSITY, Department of Materials Engineering, Box 7907, Raleigh, NC 27695-7907

R. F. Davis
J. H. Hren
D. A. Koester

232-240. NORTON COMPANY, High Performance Ceramics, Goddard Road, Northboro, MA 01532-1545

N. D. Corbin
R. Cravens
D. J. Devlin
M. Foley
S. D. Hartline
J. N. Panzarino
G. J. Sundberg
R. L. Yeckley
C. Willkins

241. NUCLEAR & AEROSPACE MATERIALS CORPORATION, 16716 Martincoit Road, Poway, CA 92064

G. B. Engle

242. OFFICE OF SCIENCE AND TECHNOLOGY POLICY, Old Executive Office Building, 175th Street and Pennsylvania Avenue, Washington, DC 20506

W. D. Phillips

243. OKLAHOMA STATE UNIVERSITY, Physics Department, Stillwater, OK 07478

C. Allison

244. OPTICAL COATING LABORATORY, 2789 Northpoint Parkway, Santa Rosa, CA 95407

J. Swab

245. PCC AIRFOILS, 5105 Rex McLeod Road, Stanford, NC 27330

T. Crofts

246-253. THE PENNSYLVANIA STATE UNIVERSITY, 410 Walker Building, University Park, PA 16802

L. E. Cross
G. Fox
S. K. Kurtz
C. A. Randall
A. E. Segall
K. Spear
R. Tressler
T. R. Trout

254. RELIABILITY AND PERFORMANCE ASSOCIATES, P. O. Box 53102, Knoxville, TN 37950-3102

W. Lau

255. REMAXCO TECHNOLOGIES, INC., 231 Sherway Road, Knoxville, TN 37922

M. Rawlins-Harris

256. ROCKWELL INTERNATIONAL CORPORATION, Science Center, Thousand Oaks, CA 91360

C. Bantton

257-259. RUTGERS UNIVERSITY, Center for Ceramics Research, P.O. Box 909, Piscataway, NJ 08855-0909

R. Anderson
D. Niesz
J. Wachtman

260. SAINT VINCENT COLLEGE, LaTrobe, PA 15650

Brother Norman

261. SOLAR TURBINES INCORPORATED, P.O. Box 85376, San Diego, CA 92138-5376

M. Van Roode

262-263. SOUTHERN ILLINOIS UNIVERSITY, Rural Route 10, Box 99B, Carbondale, IL 62981

W. Trimble
D. E. Wittmer

264. SOUTHERN UNIVERSITY, Mechanical Engineering Department, Baton Rouge, LA 70813

A. Mirshams

265. SPALDING SPORTS WORLDWIDE, 425 MEADOW STREET, P.O. Box 901, Chicopee, MA 01021-0901

T. C. Walton

266. STANDARD OIL ENGINEERED MATERIALS, 501 New York Avenue, Falcon, NY 14733

A. R. Lebold

267-269. TELEDYNE ALLVAC, P.O. Box 5030, Monroe, NC 28110-0531

B. P. Hudson
R. L. Kennedy
S. Taylor

270. TENNESSEE CENTER FOR RESEARCH AND DEVELOPMENT, Institute of Resonance Ionization Spectroscopy, 10521 Research Drive, Suite 300, Knoxville, TN 37932

J. E. Parks

271. TENNESSEE TECHNOLOGICAL UNIVERSITY, Center for Manufacturing Research, Brown Hall, Room 222, Cookeville, TN 38505

T. C. Ramaraj

272-275. TEXTRON SPECIALTY MATERIALS, 2 Industrial Avenue, Lowell, MA 01851

J. D. Casey
D. Giannelli
E. Honig
R. Krutenat

276-278. THERMACORE INC., 780 Eden Road, Lancaster, PA 17601

G. Y. Eastman
D. M. Ernst
J. R. Hartenstine

279. THERMO CERAMICS, INC., Box 923, Augusta, GA 30903

M. Katagiri

280-281. THIRD MILLENNIUM TECHNOLOGIES, INC., 408 Cedar Bluff Road, Suite 383, Knoxville, TN 37923

S. C. Weaver
S. G. Padron

282. TUSKEGEE UNIVERSITY, Tuskegee, AL 36088

S. Jeelani

283. UNION CARBIDE CORPORATION, 1500 Polco Street, Indianapolis, IN 46224

A. Sue

284-285. UNIVERSAL ENERGY SYSTEMS, INC., 4401 Dayton-Xenia Road, Dayton, OH 45432-1894

R. S. Bhattacharya
V. Srinivasan

286. THE UNIVERSITY OF ALABAMA-TUSCALOOSA, School of Mines and Energy Development, P.O. Box 870204, Tuscaloosa, AL 35487-0204

J. R. Levine

287. UNIVERSITY OF ARIZONA, Department of Materials Science and Engineering, Tucson, AZ 85721

B. Fabes

288. UNIVERSITY OF CALIFORNIA-DAVIS, Department of Mechanical Engineering, Davis, CA 95616

J. C. Gibeling

289. UNIVERSITY OF CALIFORNIA-SANTA BARBARA, Santa Barbara, CA 93106

F. F. Lange

290-291. UNIVERSITY OF CALIFORNIA-LOS ANGELES, Department of Earth and Space Sciences, 405 Hilgard Avenue, Los Angeles, CA 90024

P. Bird
A. Gratz

292. THE UNIVERSITY OF DAYTON RESEARCH INSTITUTE, 300 College Park, Dayton, OH 45469-0001

N. L. Hecht

293-294. UNIVERSITY OF DENVER, Engineering Department, University Park, Denver, CO 80208

D. Ballard
P. K. Predecki

295-298. UNIVERSITY OF FLORIDA, Department of Materials Science and Engineering, Gainesville, FL 32611

D. E. Clark
M. J. Kaufman
A. Marrone
S-M. Sim

299. UNIVERSITY OF ILLINOIS, Department of General Engineering, 117 Transportation Building, 104 S. Mathews Avenue, Urbana, IL 61801-2996

H. LM D. Reis

300-305. UNIVERSITY OF ILLINOIS, Department of Materials Science and Engineering, 105 South Goodwin Avenue, Room 212A, Urbana, IL 61801

A. Burreson
J. P. Chu
J. Homeny
M. A. Kelly
J. M. Rigsbee
M. M. Shaw

306. UNIVERSITY OF KENTUCKY, Center for Applied Energy Research, 3572 Iron Works Pike, Lexington, KY 40511-8433

B. H. Davis

307-310. THE UNIVERSITY OF MICHIGAN, Materials Science and Engineering, 2201 H. H. Dow Building, Ann Arbor, MI 48109-2136

W. C. Bigelow
J. W. Jones
S. D. Nunn
T. Y. Tien

311. UNIVERSITY OF MINNESOTA, Department of Chemical Engineering and Materials Science, 421 Washington Avenue SE, Minneapolis, MN 55455

M. L. McCartney

312. THE UNIVERSITY OF NEW MEXICO, Department of Chemical and Nuclear Engineering, Albuquerque, NM 87131

A. K. Datye

313. THE UNIVERSITY OF TENNESSEE, Department of Geological Sciences, Knoxville, TN 37996

J. Shireman

314-322. THE UNIVERSITY OF TENNESSEE, Materials Science and Engineering, Daugherty Engineering Building, Knoxville, TN 37996-2200

C. Brooks
J. F. Fellers
M. J. Godbole
K. K. Khan
Y. C. Lin
C. D. Lundin
A. J. Pedraza
J. E. Spruiell
S. D. Webb

323. THE UNIVERSITY OF TENNESSEE, Center for Materials Processing, 101 Perkins Hall, Knoxville, TN 37996-2000

J. C. Danko

324-327. THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE, Center for Laser Applications, Tullahoma, TN 37388-8897

B. Boss
N. B. Dahotre
M. H. McCay
T. D. McCay

328-331. UNIVERSITY OF UTAH, Department of Materials Science and Engineering, Salt Lake City, UT 84112

D. Drobeck
T. B. Jackson
K. M. Prettyman
A. V. Virkar

332. U.S. BUREAU OF MINES, Tuscaloosa Research Center, P.O. Box L, Tuscaloosa, AL 35486

L. Sadler

333-338. VANDERBILT UNIVERSITY, Box 6309 Station B, Nashville, TN 37235

G. Bertero
L. Hall
W. H. Hofmeister
R. Kegley
R. A. Poggie
J. J. Wert

339-342. VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, Materials Engineering Department, 301 Burruss Hall, Blacksburg, VA 24061

J. J. Brown
R. Gordon
S. M. Van Aken
D. Young

343. WQED - THE INFINITE VOYAGE, 3171 Los Seliz Blvd., Suite 201, Los Angeles, CA 90039

R. Corsini

344-349. DOE, OFFICE OF ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, Office of Transportation Technologies, Forrestal Building, CE-151, 1000 Independence Avenue, Washington, DC 20585

A. A. Chesnes
L. Divone
J. J. Eberhardt
R. B. Schulz
T. Vojnovich
A. M. Zerega

350. DOE, P.O. BOX 10940, Pittsburgh, PA 15236-0940

E. Ramer

351. DOE, OAK RIDGE OPERATIONS OFFICE, P.O. Box 2001, Oak Ridge, TN 37831-8600

Office of Assistant Manager for Energy Research and Development

352-361. DOE, OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION, P.O. Box 62, Oak Ridge, TN 37831

For distribution by microfiche as shown in DOE/OSTI-4500, Distribution Categories UC-332 (Ceramics/Advanced Materials) and UC-365 (High Temperature Materials).